THE GEOGRAPHICAL DISTRIBUTION

OF

DISEASE

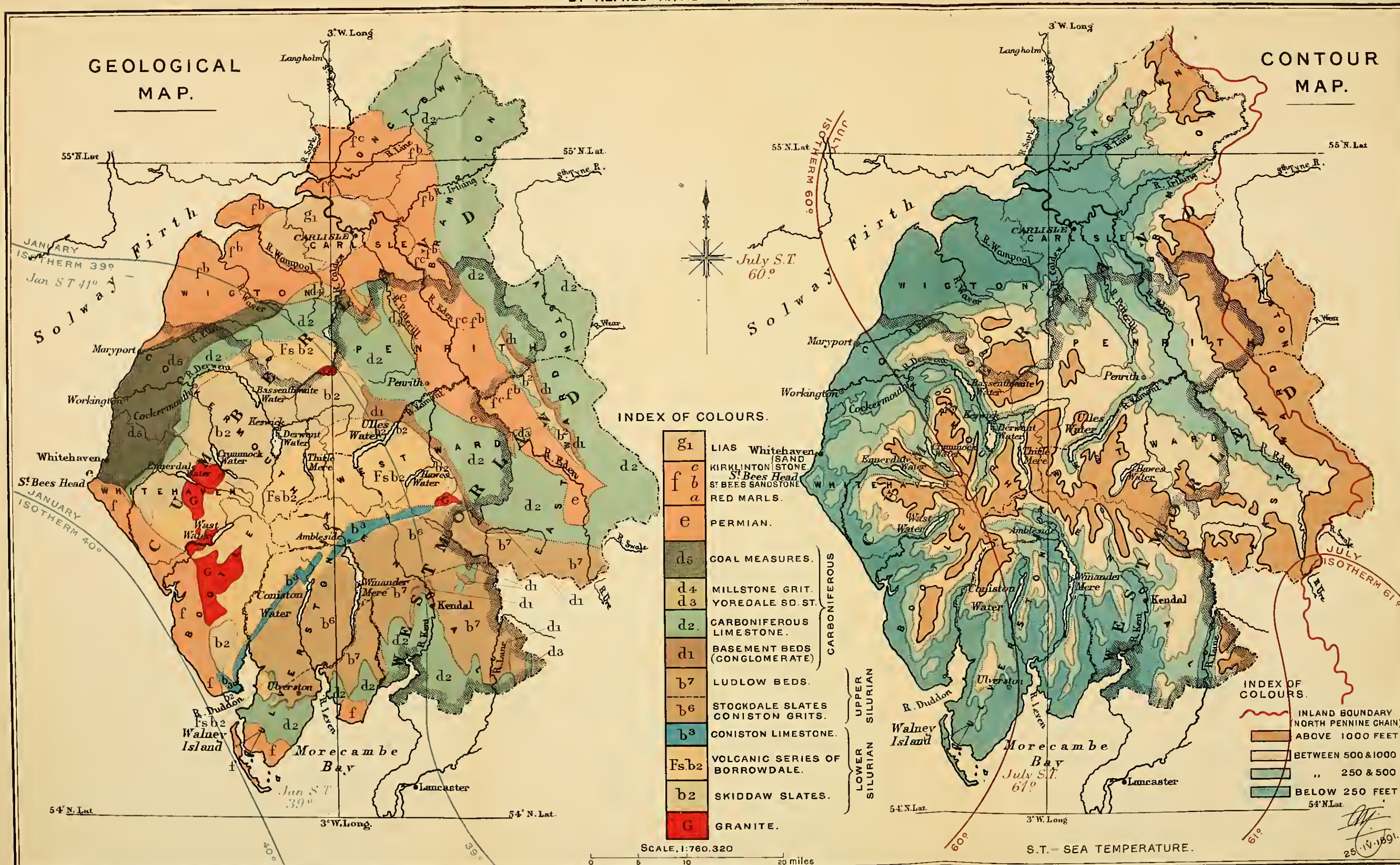
IN

GREAT BRITAIN

THE GEOGRAPHICAL DISTRIBUTION OF DISEASES:

MAPS OF THE GEOLOGY AND CONFIGURATION OF THE ENGLISH LAKE DISTRICT, CUMBERLAND AND WESTMORLAND,

BY ALFRED HAVILAND, M.R.C.S.E., &c.



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DISEASE

IN

GREAT BRITAIN

BY

ALFRED HAVILAND

MEMBER OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND; FELLOW OF THE ROYAL MEDICAL AND CHIRURGICAL SOCIETY, LONDON; FELLOW OF THE SANITARY INSTITUTE OF GREAT BRITAIN; LATE LECTURER ON "THE GEOGRAPHICAL DISTRIBUTION OF DISEASE" IN ST. THOMAS'S HOSPITAL, LONDON; AUTHOR OF "CLIMATE, WEATHER, AND DISEASE," "THE GEOGRAPHICAL DISTRIBUTION OF HEART DISEASE, CANCER AND PHTHISIS IN ENGLAND AND WALES," ETC., ETC., ETC., ETC.

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DEDICATED,

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SIR JAMES PAGET, BART., F.R.S.,

SERGEANT-SURGEON TO HER MAJESTY THE QUEEN;

SURGEON TO HIS ROYAL HIGHNESS THE PRINCE OF WALES;

D.C.L. OXON; LL.D. CANTAB. AND EDIN.; CONSULTING SURGEON TO

ST. BARTHOLOMEW'S HOSPITAL, ETC.; WHOSE NAME

WILL EVER STAND PRE-EMINENT IN THE

HISTORY OF PATHOLOGY

AND SURGERY,

WITH SINCERE RESPECT AND ESTEEM,

BY

THE AUTHOR.

PREFACE.

WHEN the publication of this second edition was first proposed, it was my intention to divide equally the materials of the first edition among the several parts of its successor, with such additions as had accrued since 1875. On reviewing, however, the material that had accumulated since the issue of the First Edition, it was considered advisable to condense within this Part all the facts and the propositions based upon them contained in the original work, so as to leave the succeeding parts, devoted to the principal river-basins of Great Britain, entirely free for the discussion of the new statistical material and the local facts connected with the natural history of certain diseases. Hence the delay in the issue of Part I., and the increase in the size of this volume.

In the first edition I had simply to describe some remarkable and hitherto undiscovered facts in the natural history of disease, and place before my readers the physical, geological, climatological, and other facts which were coincident with certain well-defined manifestations in the geographical distribution of cancer, phthisis, and heart disease.

In this second edition my function is enlarged, if not exalted, for it becomes my duty, not only to add the results of ten years more deaths (1861–70) to those I first published (1851–60), but to show how the later disease-facts agree with the earlier, and how by their so doing the geographical manifestations, which were once only spoken of as coincident with certain other facts connected with the local soils and climates, may now be regarded as having a closer and more clearly-defined relationship.

Had the geographical distribution of deaths from Cancer, Phthisis, or Heart Disease throughout England and Wales during 1861–70 differed in any essential character from that observed during the preceding decade, 1851–60, I would not have embarked on the costly undertaking of which this volume forms the first part. The same field, however, that I surveyed in 1868 with the death-roll of 1851–60 from these causes in hand, I have again carefully gone over, and studied it by the light of the later list of killed occurring during 1861–70, and have found that in the 630 districts, into which Eng-

land and Wales are divided for the registration of deaths, it was as easy to discover in which the contests were severest with either of the above disease foes, and in which resistance was either more successful or the enemy in smaller force. The maps of these two separate campaigns had then only to be laid side by side to demonstrate the facts, that the fields of the deadliest struggles with either Cancer, Phthisis, or Heart Disease in the 1851–60 campaign were identical, in the majority of cases, with those marked on the map for 1861–70; and that the least deadly fields of the earlier corresponded with those of the later decenniad.

The fact, therefore, being established, that in certain well-defined areas throughout England and Wales, Cancer, Phthisis, and Heart Disease had for twenty years consecutively caused high death rates, whilst in other equally well-defined areas they had failed to exceed their average death-rate in the country, it is evident that if we desire to search for the causes of this unequal but apparently fixed distribution, we must no longer be contented with the mere statement that certain geographical facts in the distribution of disease are coincident with certain other facts connected with the soil and atmosphere, for the time has arrived when the cause of the disease itself must be thoroughly investigated, and its relation to the soil and the atmosphere ascertained.

This is no new research, for it originated in the great medical school of Cos, which flourished more than 300 B.C., and had published before that early date the remarkable work entitled "On Airs, Waters, and Places," in which were embodied the principles, on which their disciples should investigate the relations between disease and man's surroundings: these surroundings being the air, the water, and the soil.

Up to within a very brief period the results of such researches have only been used empirically by the medical practitioner, for the conditions of soil and air that were discovered to be associated with the existence of certain diseases within their reach, could only be regarded in the light of coincident conditions; whilst the latent *veræ causæ* remained unrevealed.

Since 1868, however, when I first announced (*a*) that Cancer was more fatal among women in clayey flooded areas than on elevated calcareous soils; (*b*) that Heart Disease and Rheumatism were more fatal in the unventilated valley-system of England and Wales than in the open areas freely exposed to the prevailing winds and sunshine; (*c*) and that those tainted with Phthisis succumbed readily to the full blast of prevailing winds; the powerful aid of the microscope has been invoked, and in some specific forms of diseases has detected *flagrante delicto* some of these long hidden *veræ causæ* at their deadly work. True, the hidden cause of Cancer still baffles the most expert microscopist; so did the cause of Tuberculosis and many another pathogen in times gone by; the cause too of the Rheumatism that is

at the root of our national Heart Disease, still remains undetected in the malarial miasm of the pent-up valley, where death from cardiac and other affections of the circulatory organs abounds.

With the increase of facts and the corroboration they brought of the views set forth in the first edition, a desire has gradually been spreading to see the coincidences on which certain propositions have been based, explained by the light of a more thorough investigation of all that connects the blood and cellular structure of the human bodies with their environment.

Robert Gordon Latham, in his work on "The Varieties of the Human Species," says: "Every one knows not only that there are such men and women as negroes and whites, and that there are such things as warm and cold climates, but also that, as *a general rule*, the negro comes from a hot, the white from a temperate country. To know this leads to the admission that certain physical differences connected with the earth's surface exercise a certain amount of influence upon the human organization; though whether it be great or whether it be small, whether it be sufficient or insufficient to account for all the varieties of our species is another question. One thing alone is certain: viz., that there is *something* in soil, climate, and nutrition." Now in that "*something*" we expect to find the link connecting the earth's airs, waters, and soils with our bodies.

Before, however, entering upon such an investigation, these geological and meteorological factors must be studied carefully in every district, the diseases of which are more or less due to indigenous causes, or to exotic causes that find congenial soils and other surroundings within them.

Such a subject as disease distribution cannot progress without many workers. I have therefore endeavoured in this edition to facilitate the investigations of local observers by giving as fully as possible details in my chapters on the physical geography, geology, and meteorology of the area discussed in this part.

I am much indebted to Mr. Robert Russell, F.G.S., late of H.M. Geological Survey, for the great assistance he so kindly afforded me in the construction of the geological map. In the chapter on meteorology the well-known name of George James Symons, F.R.S., stands out prominently, as it should do, for no one has worked more laboriously or successfully than he has done in the field of British meteorology. To Dr. Alexander Buchan, M.A., I am also much indebted for the valuable aid his reports on mean temperature, wind direction, and barometric pressure in the British Isles, have afforded me.

Finally, I must heartily thank those who have helped me with their special knowledge of some of the subjects treated in this part, amongst whom are Dr. John Beddoe, F.R.S.; Chancellor Richard S. Ferguson, M.A., F.S.A.; W. Roger Williams, F.R.C.S.; H. B. Woodward, F.G.S., whose admirable work on "The Geology of Eng-

land and Wales," I have extensively quoted; William Marriott, Sec. F.R. Met. Society; to the artist at the Lithographic Establishment, who bestowed so much care on the geological, contour, and disease maps; to Mr. Joseph Martindale, who supplied me with a list of the limestone plants in the Lake District; and to Mr. Edward Best, F.G.S., and his colleagues at the Geological Survey Office, whose ever ready help has been freely accorded to me, not only whilst this work was in hand but for many years previously.

To Mr. Henry T. Butlin, F.R.C.S., Surgeon to St. Bartholomew's Hospital, I shall always feel indebted, not only for the kind interest he has felt in this work, but for his impartial and valuable report to the Collective Investigations Committee of the British Medical Association, on that part of the first edition which related to cancer.

The temporary loss of the whole of the manuscript of the chapter on the Physical Geography of the Cumbrian and Lake District contributed to the delay, as it had to be rewritten. When this had been done, the missing sheets were returned to me by post.

Medical Geography, studied in connection with geology, climatology, and physical geography, offers a wide field to the student of etiology, which must be well cultivated if he would study successfully that most essential branch of the natural history of disease.

In the Appendix will be found some data which will be of service to those who propose carrying on the investigations in Cumberland, Westmorland, and the Lake District; and should the observer proceed to mapping, the skeleton sanitary diagrams of the counties issued by the Ordnance Survey Office, will materially assist him. These skeleton maps are on a scale of four miles to one inch, and they contain the boundary lines of all the civil parishes which are included in this Appendix. Each registration district is well defined, as in the small maps illustrating this work, the boundaries of which can be transferred to blank paper and then coloured according to scale.

For the preparation of the Index I am mainly indebted to the kind help of Mr. R. H. Skaife, Editor (for the Surtees Society) of "Kirkby's Inquest of Yorkshire."

The classical work of Professor James Geikie, D.C.L., F.R.S., "The Great Ice Age," has been of signal service to the author, for which he desires to render his best acknowledgment.

Whilst these pages were going through the press, geology sustained a severe loss by the death of Sir Andrew C. Ramsay, from whose work on the "Physical Geography and Geology of Great Britain," I have extensively quoted, and will still continue to quote in the future parts of this work.[1]

A. H.

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[1] Part II. "The Climatology, Geology, and Disease Distribution of the Basin of the Thames," will be published next.

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THE GEOGRAPHICAL DISTRIBUTION OF DISEASES.

PART I.

CUMBERLAND, WESTMORLAND,

AND THE

LAKE DISTRICT;

THEIR CLIMATOLOGY, GEOLOGY,

AND

DISEASE DISTRIBUTION.

INTRODUCTION.

THE several subjects discussed in this part will be taken in the following order:—

1. The origin and object of the whole inquiry in its earliest stages, or during 1868–1875.

2. The facts, and propositions based on them, relating to the geographical distribution of *heart disease*, *cancer*, among females, and *phthisis*, among females, in England and Wales, but especially in the counties of Cumberland, Westmorland, and the Lake District, contained in the first edition of this work, published in 1875.

3. A general description of the area, including its coastal and inland boundaries, hydrography, physical geography and geology, populations, and, lastly, its general and local meteorology and climatology.

4. The geographical distribution of the following groups of diseases and causes of death: (1) *Diseases of the heart and circulatory organs;* (2) Malignant diseases under the head of *cancer;* (3) Tubercular disease of the lungs under the head of *phthisis*. These three groups will be illustrated by four coloured maps of the entire area. Then will follow an examination of the distribution of certain hitherto uninvestigated disease-groups, which have appeared to the author as likely to throw additional light upon the effect of local climates on medical geography, as determined by the physical configuration, geological and other characters of the registration districts comprised within the area under consideration. These added groups of causes of death are (4) *Diseases*

of the stomach and liver, (5) *Diseases of the kidneys*, and (6) *Metria*, including the fatal *diseases and accidents of childbirth.*

5. The reader, having had laid before him the general facts connected with disease-distribution in the counties and districts, the coincident facts connected with the geology, physical configuration and hydrography, local climatology, meteorology, and flora of each district, ethnology, populations and their age periods will finally be discussed, together with any other facts that may be culled from agriculture; a branch of science that has been from earliest history to the present day always considered to be intimately linked with medicine, by means of the study of local soils and local climates, as essential to the medical practitioner as to the agriculturist, if they would fulfil their important functions with benefit to their fellow creatures.

6. A brief summary of results already obtained will be given, and the probable future development of the investigation considered.

CHAPTER I.

Early experiences of weather and disease—The cholera in 1849—Effects of calms and winds on—Dr. Farr—Schönbein and ozone, 1848—Hippocrates—"Climate, Weather, and Disease"—Boudin—Littré—Dr. Farr's First Supplement for 1851–60—"Hurried to Death"—Railway Travelling—Dr. Druitt—First edition of this work—Major Graham, Dr. Farr, Capt. Clode—Calms and Cholera—Hingeston—Calms during Pestilences—Hippocrates—The importance of the great river inlets—How they first directed the course of the earliest invasion by animals and by man himself—English Channel—Professor James Geikie—The inlets around the English and Welsh coasts—Dr. Archibald Geikie on 'Britain joined to the Continent and its subsequent isolation—Glacial period—Advent of man—The importance of the river valleys in the study of disease distribution—Their relation to the medical geography of heart disease, cancer, and phthisis.

ALTHOUGH the year 1868 was the first in which the results of my medico-geographical investigations were published, in the form by which they are now known, the origin of the study must be dated back nearly another twenty years—namely, to 1849, during the autumn of which year I had the medical charge of my native town, in the West of England, at the time of the direful visitation of Asiatic cholera epidemic of that year. For two months I undertook to attend to all the cholera cases, whether paupers or not, that occurred in a borough of less than 12,000 inhabitants.

The epidemic lasted nearly four months,[1] and during that time two hundred and eight deaths from cholera and choleraic diarrhœa were registered within the town boundaries, so that

[1] From August 8th to December 1st, 1849, inclusive.

the deaths from these causes alone were equal to an annual rate of 57·7 per 1000. At the time of my attendance on my cholera patients I was taking meteorological observations, not only at the usual regular periods, but at various times of the day and night, as regards the *winds*, and among the results noted the following coincident facts:—(1) Whenever well-established *calms* prevailed over the infected area, there was at once an increase in the number of *fresh cases of cholera;* (2) on the other hand, whenever the air was disturbed by equatorial currents, from south to west by south-west, blowing strongly, the number of fresh cases from cholera was *immediately reduced;* (3) these opposite conditions of the atmosphere alternated several times with each other, and invariably with the same effect on the lists of fresh cholera cases.

The late Dr. William Farr, C.B., F.R.S., during one of the cholera epidemics, on comparing the *mortality* from cholera in London with the meteorological observations of Mr. James Glaisher, F.R.S., found that, during "calms," this disease was always intensified, as evidenced by the greater mortality from it.

The year 1848 is memorable among meteorologists from the fact that Schönbein then first made known his discovery how to detect *ozone* in the atmosphere by means of white blotting paper saturated with a solution of potassium-iodide and starch. To England, during 1853, these papers were brought, a corps of observers formed, and I was among the first to join, at the request of my friend G. J. Symons, F.R.S.; and I well remember the deep impression some of the results of my observations made upon me, for I very soon found that the "calms" and "strong equatorial winds," which I had noted in 1849, when tested by the ozone paper, produced very different effects on it; for during *calms* the little white slip of paper would hang for days without indicating any ozone in the air by turning *brown;* whilst, on

the other hand, immediately the wind blew strongly from the southerly quarters named, it would assume a dark-brown colour, and when immersed in water, reveal the beautiful dark violet hue from which *iodine* derives its name.

After this experience I found that what was true of cholera is true of many other diseases, as will be seen in the sequel; the reason why Hippocrates cautioned his disciples against "stuffy hollows" became apparent, as well as the necessity for studying, in connection with the circulation of the air, the configuration of the land and the planning of our roads and streets.

On further study of the works of the great founder of medicine, who wrote the results of his long and wide experience four hundred years [1] before the Christian era, it became evident, even at that early period, he had formed the opinion that without an intimate knowledge of the physical geography of an area it would be impossible to predicate its local climates and diseases. It became evident too that in this respect the father of medicine was far in advance of many of his successors as regards the effects of local configuration, soil, and aspect on climate and disease, and that it only required a perusal of his "Airs, Waters, and Places," [2] his "Aphorisms," and the first and third books of his "Epidemics," to convince the reader at once of the good grounds for this opinion.

In 1855, with the view of bringing before my brother medical practitioners an epitome of the observations of Hippocrates, I published my first work on "Climate, Weather, and Disease," in which, amongst other subjects, the mortality from phthisis in relation to atmospheric temperature was considered. This led to a correspondence with the eminent

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[1] Born at Cos, now Stanco, about B.C. 460; died at Larissa, in Thessaly, about B.C. 357, aged 104 years.

[2] "Περὶ Ἀέρων, Ὑδάτων, Τόπων." Ed. Littré. Tom. ii. pp. 12–93.

French physician and medical geographer, Boudin, who, shortly after, published his "Géographie Médicale," based principally on the statistics of the French army. At that time Dr. Farr had not published his first supplement to the Registrar-General's Reports, and therefore a medical geography for England and Wales would have been a difficult, if not an impossible, task.

In 1861 Monsieur E. Littré completed the tenth and last volume of his splendid edition of the "Œuvres Complètes d'Hippocrate," and in referring to my work, just mentioned, confirmed my opinion expressed above, in these words, "C'est Hippocrate qui, le premier, a institué la doctrine des climats, acceptée sans conteste jusque dans nos derniers temps." (Tom. 10, xxxvi.)

In 1864 Dr. Farr published his first decennial supplement to the Registrar-General's Twenty-fifth Annual Report, which rendered the geographical distribution of disease in England and Wales a possibility. This supplement afterwards formed the basis of the first edition of this work, and will be again referred to later on.

In the early part of 1868 there occurred on the platforms and in the carriages of our railways many startling sudden deaths, attributed by medical witnesses at the inquests to "heart disease," death having been accelerated by hurrying to catch the trains. The effect of railway travelling, and of the hurry consequent on it, was discussed by medical men, medical journals, as well as by the public and general press, especially in reference to the supposed increase of mortality from this cause, as a sequel to the altered mode of travelling: the substitution of the more headlong train for the leisurely coach. This alleged increase in the death-rate from heart disease was popularly supposed to be particularly marked along those lines of railway radiating from London, on which so many merchants, clerks, and others had their private residences, to and from which they travelled daily.

In February, 1868, a woman with a contraction of the aorta just where it springs from the heart hurried to one of the underground railway stations immediately after a hearty meal. She succeeded in catching the train, but she lost her life. The full stomach, the diseased vessel, and the sudden emotion and exertion were enough in themselves to bring about such a catastrophe, without calling to their aid the infernal atmosphere of this subterranean line. Almost immediately succeeding this case was that of a well-known farmer in Somersetshire, who, shortly after entering a railway carriage, suddenly felt a tickling in his throat, vomited blood, and died before assistance could be rendered. He had been accustomed to the old-fashioned mode of going to market, but since the opening of the new line he had availed himself of it, and hurrying to catch the train, found too late that he had carried about with him for years, in his most vital organ, an unsuspected flaw, which only required hurry and strong emotion to become fatal.

While these and several other cases that had occurred in other parts of the country were fresh in the public memory, the late Dr. Robert Druitt asked me to write an article calling attention to the folly of hurrying to catch trains. This I did, and what I wrote was published in *The Medical Times and Gazette* on February 22nd, 1868, under the heading "Hurried to Death," and was reprinted in pamphlet form, with considerable additions, in the autumn of the same year, under the same title.[1]

It was in this reprint that I first gave the results of my investigations as to the geographical distribution of heart disease, which I had undertaken in order to test the soundness of the prevailing opinion, that the new mode of travelling

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[1] "Hurried to Death," especially addressed to railway travellers. (Henry Renshaw, 356, Strand; and W. Mitchell & Co., 39, Charing Cross, London.)

by railways was the cause of the supposed increase of that cause of death.

Immediately after writing the article in the preceding February I had consulted Dr. Farr's first supplement to the Registrar-General's Twenty-fifth Annual Report for the ten years 1851–1860, and tabulated the death-rates, so as to enable myself to devote a chapter (pp. 42–49) to the "Geographical Distribution of Heart Disease in England and Wales," in which I foreshadowed the results that I first published in a paper read before the Medical Society of London. In this preliminary chapter I gave a diagram roughly showing the mortality from heart disease according to aspect throughout the country. This was my first attempt at illustrating the subject. My next was by mapping; and as England and Wales are divided into six hundred and thirty Registration Districts, this became a possibility. My efforts to carry out this mode of plotting and colouring, according to scale, the death-rates in each district during the ten years 1851–1860 was facilitated in every way by the late Major Graham, Registrar-General, who placed the registration maps at Somerset House at my disposal, and a room to work at them in; in addition to which I had the great advantage of the late Dr. Farr's advice and Captain William Clode's ever ready assistance.

I have now brought the history of my investigation down to 1868, and before proceeding further must draw attention to the curious fact that instead of the high mortality districts being in the course of the railways radiating from London and other large centres, they were to be found chiefly in those parts of the country characterized by the "stuffy valleys" of Hippocrates, where stagnation, rather than hurry, prevailed, and where atmospheric "calms" were most frequent, and where the "struggle in life" was least. This we shall see well exemplified in the following pages; and as regards the progress of the investigation subsequently to

1868, this will be given in the introduction to the chapters on Heart Disease, Cancer, and Phthisis.

The interesting observations of Dr. Farr, Mr. Hingeston,[1] and others on the significant connection between a *calm* state of the atmosphere and an increase in the fresh cases of cholera, and in the mortality from this cause, were anticipated by Hippocrates, who noted in his "Pestilential Constitution" that the "*calms*" that prevailed during times of epidemics were accompanied and succeeded by their intensification.

Such was the origin of the present inquiry, the object of which requires but a very few words, and may be summed up under the following heads: (1) To ascertain the geographical distribution of a disease is the first step towards a knowledge of its natural history, as it is in that of the fauna and flora of a district, a continent, or of the world. (2) Thus to discover where diseases prevail, and where they do not thrive. (3) To search for, in those localities, the causes of prevalence, or absence, or scarcity, whether they reside in their local airs or waters, or are due to general or local climates, geological structure, physical configuration, or social surroundings.

But whilst these are the three fundamental objects, we may rest assured that as we proceed we shall be led, in our endeavours to attain them, to follow other branches of study, which, although they may not immediately serve our purpose, will, in the end, illuminate many a dark passage in our research.

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[1] "Climate, Weather, and Disease," p. 128. (London: John Churchill, 1855.)

CHAPTER II.

The facts, and the propositions based upon them, relating to the geographical distribution of heart disease, cancer among females, and phthisis among females, in the Divisions, Counties and Districts of England and Wales, and in the Counties of Cumberland, Westmorland, and the Lake District, contained in the first edition of this work, published in 1875—River courses as land ventilators—Dr. Koch—Recapitulation of Disease-facts—Heart Disease, Cancer, and Phthisis in the Divisions, Counties, and Districts.

FOR the sake of registration purposes, England and Wales are divided into 11 registration divisions, 44 registration counties, North and South Wales being reckoned as two, and 623 registration districts (1851–1860).

The area under consideration forms a part of two of the eleven divisions: *Cumberland* and *Westmorland* belonging to the *northern counties division*, which also contains Northumberland and Durham; whilst *the Lake District* includes parts of the two former counties and part of Lancashire, in the *north-western division*, which consists of that county and Cheshire.

In the first edition the disease-facts were grouped—(1) into those for the *divisions*, (2) those for the *counties*, and (3) those for the *districts;* and thus were gradually focussed on the unit of observation,—the *registration district*,—which, however, I shall have occasion to show ought to be divided in the decennial supplements, if not into natural groups of parishes, into *sub-districts*, of which there are 2080 in England and Wales.

The mapping of England and Wales into 11 divisions, 53

counties (each of the Welsh counties being dealt with separately), and 623 registration districts, affords us the means of analysing the distribution of any of the specified causes of death contained in the list of the decennial supplement. By this threefold division we are enabled to sift our disease-facts through three gauges of different degrees of fineness.

In the first place, we see what proportion the annual number of deaths from a cause of death bears to the population in each of the eleven *divisions;* we colour *blue* or *red* those divisions which are *above* or *below* the average of the country, and then study this gross distribution carefully. Our next process is to colour the *counties* in the same way, and observe what counties dominated that of the divisions; and our third process is to discover how the proportional mortality of each county is influenced by the mortality in the *districts.* Having done this, we review our maps on which are displayed our disease-facts, and then go through systematically the salient geographical, physical, geological, climatological, hydrographical, and social features of each of the divisions, counties, and districts, so as to enable ourselves to observe the coincidences that may exist between the disease-facts and the characteristic features of the several areas under discussion. If during this scrutiny we discover a general law regulating the distribution in each of the three classes, namely, divisions, counties, and districts, our last duty is to crucially test the apparent relation of the marshalled facts one with the other, separate the real from the apparent, study the exceptions, and examine their relation to the assumed law. I say assumed law, for we must remember that until it has been proved it cannot be regarded as a law at all. At the same time, we must bear in mind that in all investigations some hypothesis is requisite, in the first instance, to aid us in our inquiry. There is, however, no need whatever for dogmatically laying down the law at all. Throughout my investigations I have simply stated the

results in the form of propositions, in which I have stated that certain disease-facts are coincident with certain other facts connected with the physical character and climate of the district under investigation. All I endeavour to do is to place the facts before my readers in such a manner as to render their being easily studied in connection with one another, reserving, however, for myself the right of expressing my views on the connection between the several facts, and of giving the results of my experience whilst doing so.

The three diseases I first mapped showed at once how widely they differed from each other in their geographical distribution as early as the *division* stage. For instance, when the division maps were coloured as described, it was at once seen, (1) in the *Heart Disease* map, that those divisions to which the sea winds had the readiest access, in consequence of their low fore-shores, broad estuarial openings, and the courses of their river-valleys in the directions of the prevailing winds, were coloured so as to represent the *lowest* divisional *mortality*—such as London (I.), the Eastern Counties (IV.), Yorkshire (IX.), North-Western (VIII.), and Wales (XI.). On the other hand, the divisions that are the most shut in from the sea, the most midland, in fact, the South-Midland (III.), and the West-Midland (VI.), and those that are begirt by high, precipitous coast cliffs, have the courses of their rivers running at *right angles to the prevailing winds* and *tidal wave*, instead of in the same direction, were coloured so as to represent the *highest* divisional mortality from heart disease.

At this point I shall not dwell longer on these facts, as we shall have ample opportunities later on of illustrating them; but I must ask the student to think over in connection with them what was stated in the last chapter with regard to the effect of "calms" or stagnant air on epidemics, as observed by Hippocrates and Dr. Farr; and the former observer's "stuffy valleys."

(2) In the *Cancer* (among females) Division map,[1] coloured in accordance with the death-rate scale of shades of *blue* and *red*, like that of heart disease, a totally different arrangement of high and low mortality struck the eye, the high and low mortality divisions being arranged in three groups, having each a north-easterly and south-westerly direction, as follows :—(*a*) The most south-easterly group, characterized by the tertiary, and more recent clays and other retentive soils, by fully formed rivers, such as the Thames, which seasonally flood the adjacent districts, consist of London (I.), the South-Eastern Counties (II.), the South-Midland Counties (III.), and the Eastern Counties (IV.), was coloured so as to represent a very *high mortality* from this cause; whereas the most north-westerly group, characterized by elevated land, composed of the oldest rocks, Cambrian, Silurian, Carboniferous, Limestone, etc., where the rivers are seldom fully formed, and still more seldom cause widespread and lasting floods, are torrential rather than sluggish, was coloured so as to represent the *lowest mortality*. This division consists of the Monmouthshire and Wales Division (XI.), and the North-Western Counties (VIII.), in which lies a part of the Lake District. The intermediate low mortality group, coloured so as to represent an intermediate stage, stretched from Northumberland to Cornwall, and consisted of divisions in which the geological features mainly consist of the older or palæozoic rocks, although, immediately to their south-east and east, the secondary rocks flank them. In these divisions the elevated and unflooded land are of considerably larger areas, and more densely populated than the lower parts subject to floods. These divisions are the Northern Counties (X.), in which Cumberland and Westmorland are, York-

[1] The maps showing "The Geographical Distribution of Cancer (Females), 1851–1860, in the Registration Divisions and Counties, at All Ages," are here reproduced from the first edition (1875) of this work, pp. 68 and 72 respectively.

shire (IX.), North-Midland (VII.), West-Midland (VI.), and South-Western (V.).

(3) In the *Phthisis* (among females) Division map, coloured on the same principle as the two first, we find a totally different arrangement of colouring, which, however, is sufficiently simple not to require much description. In the Heart Disease map we found all the divisions that were exposed to the full and unimpeded afflux of the prevailing sea winds, in all their strength and force, characterized by the *lowest* mortality. In the Phthisis maps we find the *highest.*

In the Heart Disease map we found that all the divisions that may be classed as midland, are shut in from the sea, protected, in fact, from the full force of the strong winds; that those divisions that were protected by a steep, precipitous coast-line of cliffs, in which the axes of the rivers were at *right angles* to the directions of the prevailing winds and the tidal wave, were coloured so as to represent the highest mortality from this cause. In the Phthisis map these very same divisions have the *lowest* mortality. The *exposed divisions* having the *highest mortality* from Phthisis were—Monmouthshire and Wales (XI.), North-Western Counties (VIII.), Yorkshire (IX.), North-Midland (VII.), and Eastern Counties (IV.). The protected divisions having the lowest mortality were—the Northern Counties (X.), in which are Cumberland and Westmorland, the West-Midland (VI.), the South-Midland (III.), the London (I.), the South-Eastern (II.), and the South-Western (V.).

Such are the simple facts as regards the distribution of the above three groups of causes of death in the registration divisions into which England and Wales are divided. It must be remembered that the above remarkable groupings of high and low mortality plotted on the three maps were not the outcome of small numbers collected within a short period; for in the case of heart disease there were 236,973 deaths,

of cancer (among females), 42,137, and of phthisis (among females), 269,618, in all more than half a million deaths—548,728—all occurring within the ten years 1851–1860.

We cannot ignore the power of such numbers, nor the fact that these numbers have really grouped themselves, for the groupings are the result of the mortality proportional to the populations which existed in each of the 623 districts, 53 counties, and 11 divisions.

We shall next study the distribution of the three diseases in the counties, and note how their mortality influenced that of the divisions, taking them in the order observed above.

In studying our subject among the *counties* and *districts*, it may help us to more quickly grasp the facts and aid our memories in retaining them if we recall the names and geographical positions of some of the remaining landmarks which still tell us of the early influence the geology of England and Wales had upon their history.

The invasions of our country were, first, from north-east, east, and south, when the old stone-age man found his way as far west, where he discovered plenty of game to hunt and live upon, which indeed had preceded him. The Arctic fox, reindeer, glutton, and other animals from the north-east; the elephant, hippopotamus, lions, tigers, and other animals *feræ naturæ* from the east, south-east, and south—all these and man himself must have crossed the undulating plains that now form the bottoms of the North Sea and English Channel, the present barriers between the British Islands and the European Continent, on foot.

The remains of these animals can be traced from Ilford, where they characterize the old Thames Valley deposits, to the Dogger Bank, renowned for its mammalian remains, a shoal about ten fathoms deep, and 120 miles north-east of Cromer, and 112 miles north-by-east of Scarborough. At this period the Rhine probably joined the Thames in its

course northwards, during which it would receive the Ouse, where similar remains have been found. It was probably on the eastern side that these early immigrants found the easiest access to the interior of the country. First there was the broad valley of the Thames to the south, then in succession towards the north they found the vast plain from which ramified towards the west and north-west the valleys of the Ouse, the Nen, the Welland, the Witham, and the Glen, now covered by the sea and known as "*The Wash.*" Still further north were the valley-inlets of the Humber, the Tees, and Tyne; all to be remembered in connection with the first advent of man and his fellow mammals to this land, and with their important relation now to their descendants' health and diseases. So much for the North Sea.

In the English Channel mammalian remains have been dredged up in the same manner as in the North Sea. This Professor James Geikie asserts in his "Great Ice Age," and, moreover, tells us that peat has been dredged up in this channel, and that sunken forests abound along the coasts of Brittany, Normandy, and the Channel Islands, where trees have been observed at a depth which could not be less than sixty fathoms below high-water mark (p. 309). The valley which is now covered by the waters of the English Channel differed widely from that of the North Sea. On its English side there is not a fully formed river flowing into it; and the majority of the rivers that do fall into this channel have their courses at right angles to the south-west or nearly so. There were no broad river valleys opening into what may be termed the great ancient Seine Valley, of which the Somme is a tributary, as into that of the North Sea, which might be called the great ancient Thames Valley. The river Seine is the only fully formed river that falls into the English Channel on its south side. These facts must be borne in mind when studying the distribution of disease along the coasts of the southern and eastern counties and districts of England.

On rounding the Land's End the West Coast begins, and the great estuary of the river Severn, the Bristol Channel, is the first great inlet met with. Here Buckland and Ramsay in 1841 saw, examined, and rejoiced in the collection of the bones and teeth of mammoths, rhinoceroses, hyænas, lions, and other animals, in Caldy Island, in Carmarthenshire Bay, off the coast of Pembrokeshire, to the south of Tenby. From the main valley of the Severn up the minor valleys watered by the Avon, the Axe, and the Brue, would those animals wander that were found in the Mendip limestone caves, such as the Banwell cave, near Winscombe, and Wookey Hole, which were the source of so much wonder in my early days, and were presided over by the astute and venerable Mr. Beard, who used to rejoice in telling his visitors how he had puzzled Sir Astley Cooper, and even Dean Buckland himself. In these caves have been found thousands of bones that once formed the skeletons of the hyæna, lion, reindeer, mammoth, bear, rhinoceros, and many other species. Limestone has been the means of preserving these relics, from the fact of its solubility in waters in which were dissolved carbonic and other acids derived from rain and vegetable decomposition. These acids, held in solution by the underground waters, eat out the limestone into subterranean courses, which, owing to drainage by upheaval of the land, were eventually converted into the caves that early man and his wild companions found so convenient.

Along the west coast of Wales there are numerous inlets, which, however, are more suitable for the full play of the prevailing westerly and south-westerly winds than points for invasion by quadrupeds. Until we come to the north of the Principality we do not get limestone again preserving the relics of those animals that roamed on the broad plain between Wales and Ireland. Between Anglesey and Morecambe Bay a series of valley openings present themselves, which will be seen to exercise a wonderful influence on the local climatic

diseases and agriculture of the country between the present sea and the Pennine chain of hills, known as the "*backbone*" of England, or great central water-parting, which divides the eastern from the western watershed. With the exception, however, of Anglesey and of the Vale of Clwyd, there is no coastal limestone until we reach the Lancashire or northern coast of Morecambe Bay.

Dr. Hicks and Mr. E. B. Luxmoor explored the bone cavern in the Vale of Clwyd, and found 400 teeth of the rhinoceros, 500 of the horse, 180 of the hyæna, and 15 of the mammoth, according to Mr. H. B. Woodward, in his admirable work on "The Geology of England and Wales" (p. 543). The valleys of the Mersey, the Ribble, and the Lune all lead up to the great central water-parting of England, where limestone abounds. In the Settle Cave, Yorkshire, we have a good illustration of a collection of bones being found at a point where the valleys of rivers favoured the migrations inland of animals from the two opposite sides of England, through the openings of the valley of the Humber in the east, and through the openings on the west already named, at the higher end of which valleys are to be found the bone caverns of the Yorkshire and Derbyshire limestones. Whilst in this part of England I may note for further reference that in the description above of the distribution of heart disease the divisions formed an arch of *low mortality* along the courses of these river-valleys—that is, from the mouths of the Lancashire valleys on the west to the mouth of the Humber on the east.

After Morecambe Bay the next great inlet to the north is the Solway Firth, which will be noticed fully later on.

Thus we have found that in the old river gravels of the eastern side of England, and the limestone caves on the western, have been preserved the remains of those animals which first migrated to our country and enjoyed its primeval forests.

It has been pointed out that these animals pursued certain courses to get inland: from the vast valley plains to the east and south and west of this country, which courses at the present day are the mouths and valleys of our principal rivers.

At first sight it may appear that I have gone a little out of the way to notice the early migrations of the cave and the old river-gravel animals; but the reader must bear well in mind that the study of disease distribution compels us to take everything into consideration that at all bears either upon the natural history of man himself, or of his health and diseases—whence and why arose certain tendencies in him to succumb to one set of groups more readily than to another. With these animals man came whilst yet the British Isles were joined to the Continent; but long before the fauna arrived, the flora had preceded them, and made ready their way. We shall have to study the local floras in connection, first, with geology, and then with climate and disease. Dr. Archibald Geikie,[1] in his introductory lecture at the opening of the session of the class of geology in the University of Edinburgh, November, 1881, gave a succinct account of the condition of Britain at the time when the earliest human beings appeared in the country, which I shall presently quote.

Before our country was sufficiently elevated to become so united to the Continent as to render these migrations possible, it was in all probability submerged to a great depth below the surface of the sea. In 1831, Mr. H. B. Woodward tells us (*Op. cit.*, p. 491), Joshua Trimmer discovered marine shells, for the most part broken, in sand and gravel on Moel Tryfaēn, about five miles south-east of Caernarvon. Their occurrence suggested a great submergence in post-pliocene times. Fossils have since been obtained at heights of 1,330 to 1,360 feet. Over sixty species have been obtained at Moel Tryfaen, and of these eleven species are Arctic, of nor-

[1] "Geological Sketches at Home and Abroad," by Archibald Geikie, LL.D., F.R.S. (Macmillan and Co., 1882.)

thern forms; most of them are littoral, and the rest indicate depths of from ten to twenty fathoms. From these depths the land gradually rose, so that at the time when the earliest human beings visited it, Geikie says, there can be no doubt that the British Islands still formed part of Continental Europe. There is reason to believe that the general level of these islands may have been then considerably higher than it has been since. From the shape of the bottom of the Atlantic immediately to the west of our area, as revealed by the abundant soundings and dredgings of recent years, it is evident that if the British Islands were now raised even 1,000 feet or more above their present level they would not thereby gain more than a belt of lowland somewhere about 200 miles broad on the western border. They stand, in fact, nearly upon the edge of the great European plateau which, about 230 miles to the west of them, plunges rapidly down into the abysses of the Atlantic. It is perfectly certain, therefore, that though our area was formerly prolonged westwards beyond its present limits, there has never been any important mass of land to the west of us in recent geological times, or within what we call the human period, probably never at any geological epoch at all. Every successive wave of migration, whether of *plant* or of *animal*, must have come from the other or eastern side. But though our country could never have stretched much beyond its present limits, it once undoubtedly spread eastward over the site of what is now the North Sea. Even at the present day an elevation of less than 600 feet would convert the whole of that sea into dry land from the north of Shetland to the headlands of Brittany. At the time when these wide plains united Britain to the mainland the Thames was no doubt a tributary of the Rhine (or *vice versâ*), which in its course northward may have received other affluents from the east of Britain before it poured its waters into the Atlantic, somewhere between the heights of Shetland and the mountainous coast of southern Norway.

There is evidence of remarkable oscillations of *climate* at the epoch of the advent of man into this part of Europe. A time of intense cold, known as the Ice Age or Glacial Period, was drawing to a close. The glaciers, frozen rivers and lakes, and floating icebergs, had converted most of Britain, and the whole of Northern Europe, into a waste of ice and snow, such as North-Greenland still is; but the height of the cold was past, and there now came intervals of milder seasons, when the wintry mantle was withdrawn northward, so as to allow *the vegetation and the roaming animals* of more temperate latitudes to spread westward into Britain. From time to time a renewal of the cold once more sent down the glaciers into the valleys, or even into the sea, froze the rivers over in winter, and allowed the Arctic flora and fauna again to migrate southwards into tracts, from which the temperate plants and animals were forced by increasing cold to retreat. At last, however, the Arctic conditions of climate ceased to reappear, and the Arctic vegetation, with its accompanying reindeer, musk sheep, lemmings, Arctic fox, glutton, and other northern animals retreated from our low grounds. Of these ancient chilly periods, however, the Arctic *plants* still found on our mountain-tops remain as living witnesses, for they are doubtless descendants of the northern vegetation which overspread Britain when still part of the Continent, and before the arrival of our present temperate flora and fauna.

Previous to the final retreat of the ice, the alternating warmer intervals brought into Britain many wild animals from milder regions to the south. Horses, stags, Irish elks, roe deer, wild oxen, and bisons roamed over the plains; wild boars, three kinds of rhinoceros, two kinds of elephant, brown bears and grizzly bears, haunted the forests. The rivers were tenanted by the hippopotamus, beaver, otter, water-rat; while among the carnivora were wolves, foxes, wild cats, hyænas, and lions. Many of these animals must

have moved in herds across the plains over which the North Sea now rolls. Their bones have been dredged up in hundreds by the fishermen from the surface of the Dogger Bank.

Such were the denizens of Southern England when man made his first appearance there. It seems not unlikely that he came some time before the close of the long Ice Age. He may have been temporarily driven out of the country by the returning cold periods, but would find his way back as the climate ameliorated. Much ingenuity has been expended in tracing a succession in this primeval human population of Britain. Among the records of its presence there have been supposed to be traces of an earlier race of hunters of a low order, furnished with the rudest possible stone implements; and a later people, who, out of the bones of the animals they captured, supplied themselves with deftly-made and even artistically-decorated weapons. All that seems safely deducible from the evidence, however, may be summed up in saying that the *palæolithic* men, or men of the older stone period, who hunted over the plains, and fished in the rivers, and lived in the caves of this country, have left behind them implements, rude indeed, but no doubt quite suitable for their purpose; and likewise other weapons and tools of a more finished kind, which bear a close relationship to the implements still in use among modern Eskimos. It has been suggested that the Eskimos are their direct descendants, driven into the inhospitable North by the presence of more warlike races.

The rude hunter and dweller in caves passed away before the advent of the farmer and herdsman of the *neolithic* or later stone period. We know much more of him than of his predecessors. He was short of stature, with an oblong head, and probably a dark skin and dark curly hair. His implements of stone were often artistically fashioned and polished. Though still a hunter and fisher, he knew also how to farm. He had flocks and herds of domestic animals; he was acquainted with the arts of spinning and weaving, could make

a rude kind of pottery, and excavate holes and subterranean galleries in the *chalk* for the extraction of *flints* for his weapons and tools. That he had some notion of a future state may be inferred from arrow-heads, pottery, and implements of various kinds which are found in his graves, evidently placed there for the use of the departed. He has been regarded as probably of a non-Aryan race, of which perhaps the modern Basques are lineal descendants, isolated among the fastnesses of the Pyrenees by the advance of younger tribes. Traces of his former presence in Britain have been conjectured to be recognisable in the small, dark Welshmen, and the short, swarthy Irishmen of the West of Ireland.

When the earliest neolithic men appeared in this region, Britain may have still been united to the Continent. But the connection was eventually broken. It is obvious that no event in the geological history of Britain can have had a more powerful influence on its human history than the separation of the country as a group of islands cut off by a considerable channel from direct communication with the mainland of Europe. Let us consider for a moment how the disconnection was probably brought about.

There can be no doubt that at the time when Britain became an island, the general *contour* of the country was, on the whole, what it is still. The same groups of mountains rose above the same plains and valleys, which were traversed by the same winding rivers. We know that in the Glacial and later periods considerable oscillations of level took place: for, on the one hand, beds of sea-shells are found at heights of 1,200 or 1,300 feet above the present sea-level; and, on the other hand, ancient forest-covered soils are now seen below tide-mark. It was doubtless mainly subsidence that produced the isolation of Britain. The whole area slowly sank, until the lower tracts were submerged; the last low ridge connecting the land with France was overflowed, and Britain became a group of islands. But unquestionably the

isolation was helped by the ceaseless wear and tear of the superficial agencies which are still busy at the same task. The slow but sure washing of descending rain, the erosion of water-courses, and the gnawing of sea-waves, all told in the long degradation. And thus, foundering from want of support below, and eaten away by attacks above, the lowlands gradually diminished, and disappeared beneath the sea.

Now, in this process of separation, Ireland unfortunately became detached from Britain. We have had ample occasion in recent years to observe how much this geological change has affected our domestic history. That the isolation of Ireland took place before Britain had been separated from the Continent may be inferred from a comparison of *the distribution of living plants and animals.* Of course the interval which had then elapsed since the submergences and ice-sheets of the Glacial Period must have been of prodigious duration, if measured by ordinary human standards. Yet it was too short to enable the *plants* and *animals* of Central Europe completely to possess themselves of the British area. Generation after generation they were moving *westward*, but long before they could all reach the *north-western* sea-board Ireland had become an island, so that their further march in that direction was arrested, and before the subsequent advancing bands had come as far as Britain it too had been separated by a sea channel, which finally barred their progress. Comparing the total land mammals of the West of Europe, we find that while Germany has ninety species, Britain has forty, and Ireland only twenty-two. The reptiles and amphibia of Germany number twenty-two, those of Britain thirteen, and those of Ireland four. Again, even among the winged tribes, where the capacity for dispersal is so much greater, Britain possesses twelve species of bats, while Ireland has no more than seven, and 130 land-birds to 110 in Ireland. The same discrepancy is traceable in the *flora*, for while the total number of species of *flowering*

plants and *ferns* found in Britain amounted to 1,425, those of Ireland number 970—about two-thirds of the British flora. Such facts as these are not explicable by any difference of climate rendering Ireland less fit for the reception of more varied vegetation and animal life; for the climate of Ireland is really more equable and genial than that of the regions lying east of it. They receive a natural and consistent interpretation on the assumption of the gradual separation of the British Islands during a continuous north-westward migration of the present *flora* and *fauna* from Central Europe. The last neck of land which united Britain to the mainland was probably that through which the strait of Dover now runs.[1]

In studying disease-distribution we shall find that the river-valleys are the chief means by which the largest communities have their atmospheres changed, and it will be evident that those valleys lying in the direction of the most frequent or prevailing winds will enjoy the most complete renewal; and as it so happens that the course of the tidal wave on the western coast throughout, and on the eastern for nearly three-fourths of its extent, coincides with that of the prevailing winds, the consequent influx of waters up the river-valleys twice in every twenty-four hours must contribute to the movement of the air in the valleys, and in times when the winds do not blow up them must tend to mitigate the evils of still air. We shall find that these primeval inlets, up which the mammoth and his companions travelled when they first discovered this land, are now, as they were then, the channels by which the country was purged of its residual air. In those early days, however, the winds were not sea-winds on the eastern side, as they are now, but intensified continental currents, although those named on the west coast came straight from the Atlantic over Ireland.

[1] Dr. Archibald Geikie, *Op. cit.*

The river-valleys that open on the southern valley, it has been stated, do so more or less at right angles to the prevailing winds and tidal waves, and necessarily cannot facilitate the entrance of either wind or wave to the interior; the winds passing *over*, not up and through them, and the waves passing their mouths in its course of least resistance. On the south coast there are some exceptions, it is true, and the results of this change of position are at once seen. The geographical distribution of heart disease and the circulatory organs in Britain affords the best illustrations possible of the value of a sound knowledge of ventilation; and points to the fact that wherever the facilities are greatest for constantly changing the air, there is, coincident with these facilities, a *low mortality* from heart disease, and that where the conditions are reversed, as in pent-up valleys, badly arranged and unventilated streets, the results are reversed, as evidenced by the *high mortality*.

These river-valleys are also to be considered with regard to the rivers that made them—their length, nature of their beds, whether they are fully formed, flood their riparial districts seasonally, or whether they are torrential in their character, and, if they flood their valleys, only do so temporarily; the geological nature of the formations through which they have cut their way to the sea, whether they are retentive, like clays, or permeable, like chalk and sands. It will be presently seen (1) that, during the ten years 1851–1860 the *highest mortality* among females from malignant disease, registered under the name of *Cancer*, was to be found in those districts that are riparial to rivers that seasonally flood their adjacent lands; and that, on the other hand, the *lowest* mortality was to be found in those communities enjoying high dry conditions on the older or palæozoic rocks, especially the carboniferous-limestone, and on the secondary, such as the oolitic limestones and chalk, or where the rivers are torrential in their flow, and only flood their adjacent areas temporarily.

Then again with regard to *Phthisis*, under which name tubercular diseases of the lungs are registered—in these river-valleys, even when a certain amount of soil dampness prevails, shelter was found against the strong winds, and, coincident with their protective influence, *low* mortality from this fatal disease was the rule; on the other hand, in the valleys or on the hill-sides exposed to the full force of the winds whencesoever they came, there was to be found the highest mortalities coincident with those climatic conditions.

I have now given a brief outline of what the reader may expect to be the course which the student of medical geography will have to pursue. The physical configuration of the land he is studying must be amongst his first considerations; the river-valleys are not only watercourses, but act as ventilators more or less perfectly according to their direction in relation to the prevailing winds. Then the nature of the rocks out of which these valleys have been cut, their elevation above sea level, and their physical characters will have to be studied in their relation to the floods to which they may be subject. The effects of floods on the soil, arising from vegetable decomposition, and upon the atmosphere of the district, are important subjects for the student. In this part of his study the distribution of cancer will afford him abundant material for patient investigation. Lastly, the shelter afforded by valleys to the consumptive, and the low death-rate from this cause in some that are notably well protected from the influence of strong winds, will afford the reader abundant food for contemplation, especially when studied in connection with the effects on the mortality from exposure to the full force of the winds. The question is, Is it the simple *force* that is the fatal element in these winds, or is it some other, such as *ozone*, which finds its way straight to the tuberculous matter, attacks it, inflames its surroundings, and sloughs it out, killing the host, just like the lymph of Dr. Koch, which, when injected, is said instinctively to rush off to

seize its quarry, *tubercle*, whether it be in the lung of the consumptive or on the skin of those suffering from *lupus*. Certain it is that in one case the dose can be graduated and the case selected; in the other, however, this is often impossible; and, moreover, the ignorance on the subject is so great that the fact is hardly yet recognised that strong winds do contain a something that kills in an overdose like Koch's lymph, and apparently after the same fashion. What this something is we have to find out. Professor Koch states that he knows the nature of his lymph, and that he has revealed his secret.

Recapitulation of the Disease-Facts—Heart Disease in the Divisions.

I. A map of England and Wales, on which the relative mortality in each division is coloured *blue* or *red*, according to its being above (blue) or below (red) the average, shows that during the decennial period, 1851–1860, of the eleven great divisions, two-thirds of those divisions which had an *extensive sea-board* had a low mortality from *heart disease*, coincident with such marine boundaries.

II. It also showed that the two divisions which had little or no sea-board, but, on the contrary, were surrounded on all sides by other divisions, had a high mortality from heart disease.

III. It further showed that the coastal divisions which had a high mortality from heart disease had also coincident with it certain physical characters which obstructed the free passage of the prevailing winds up the inhabited valleys and river-courses.

Heart Disease in the Counties.

A map of the counties of England and Wales coloured on the same principles as that of the divisions showed the following facts :—

In the Northern Counties Division (X.) coloured *blue*, indicating a mortality from heart disease *above* the average,

Durham stands out conspicuously as *red* amongst its fellow counties, as it had a *low* mortality from this cause. Coincident with this, it must be remembered that at the river Tyne the geological character of this country and the direction of the rivers and valleys changed between that river and the Tees. Pursuing our course along the Eastern Coast Divisions (IX., VII., IV., I.), we find that the North and East Ridings of Yorkshire and Essex having a high mortality, whilst Lincoln, Suffolk, and Norfolk have one below the average, coincident with the high mortality on the precipitous and protecting barriers of oolite rocks, which protect from the immediate effects of the North Sea winds the North Riding, and, therefore, the mortality in this county was not inconsistent with the physical characters of the coast. Again, the East Riding from Flamborough Head to the mouth of the Humber has a low coast, and, coincident with this, its mortality from heart disease was found to be considerably lower than that of the North Riding. The map showed that the counties under the influence of the great inlets of the Humber and the Wash were all characterized by low mortality from heart disease, which in the former case extended over the backbone of the country to meet the low mortality counties under the influence of the great inlets on the Lancashire and Westmorland coasts. The Wash seemed to make its influence felt as far as the counties of Rutland and Bedford.

Along the South of England (II., V.), where I have already remarked the river-courses and sea inlets are at right angles to the prevailing winds, and therefore affording difficult access to them, only one county (Cornwall) out of the seven which form the southern sea margin had a death-rate from heart disease below the average. Cornwall is a peninsula, with all its advantages, but even with these, owing to the counteracting disadvantages, its death-rate was only just at the average (12·4).

On the western sides of England and Wales, which have

been seen to be so favourably circumstanced with regard to their sea-inlets, the direction of their valleys and river-courses, and the unbroken violence of their winds, there was not a single county from Monmouth to Lancashire which had a mortality above the average. Beyond this country, however, we found Cumberland having a mortality from heart disease above the average. Although the south-west boundary of this county has every advantage of being thoroughly exposed to the south-west wind from the Irish Sea, we must remember that the greater portion of this beautiful county is protected by the lofty transverse ridge of Cumbrian and Westmorland Hills, which separates their deep and luxuriant valleys, the north from the south.

With regard to the twenty-six *inland* counties, five only have a mortality *below* the average; and it is noteworthy that all these, without exception, are contiguous to coastal counties, which have free access from the sea through inlets such as the Humber and the Wash, on the Eastern side, and on the Welsh side, the inlets of the Dovey and other rivers from Cardigan Bay, or else are so elevated as to receive the full afflatus from the sea without interruption. The remaining twenty counties in which the death-rate from heart disease is great are all more or less protected, those counties whose towns and villages lie in deep and well-sheltered valleys, such as Herefordshire and Worcestershire, Wiltshire and Berkshire, being characterized by the highest degree of mortality from heart disease, the high death-rates of these counties causing them to stand out conspicuously on the map. We have seen, therefore, that the death-rates from heart disease and dropsy during the ten years 1851–1860 in the several counties were still coincident with certain physical characters of the country, in the same manner that we observed they were when discussing the divisional mortality. The coincidence, however, is in the counties of a more definite character.

If we group the counties in the following manner, we shall

find that a high death-rate from heart disease and dropsy was in 1851–1860 coincident with an inland or sheltered position, and that there is a certain progressive increase of mortality from the circumference of our peninsula towards its more central localities.

(1). The mean annual mortality of the entire series of the twenty-seven *coastal counties* was 11·9 to every 10,000 living.

(2). The mean annual mortality of the twenty *inland* counties was 12·5 to every 10,000 living.

(3). The mean annual mortality of the six *midland* or *central counties* was 15·1 to every 10,000 living.

We therefore remark that coincident with the *lowest* amount of exposure to the sea air, as in the *midland* counties, was the *highest* amount of mortality in those counties; and that, on the other hand, the *lowest* amount of mortality was coincident with the greatest amount of exposure; and again, that the counties which lie *intermediately* between these extremes had also an intermediate death-rate within a decimal of the average.

Heart Disease in the Districts.

Having gone so fully into the distribution of heart disease in the divisions and counties, I shall now simply recapitulate some of the more important facts bearing upon the general distribution of this cause of death among the registration districts, as this part of the work will be fully discussed, as regards the Lake District, Cumberland and Westmorland, when we reach the later stage of the inquiry. At present, in the case of heart disease, cancer, and phthisis, I shall only give an epitome of what the district maps of these diseases taught us for the years 1851–1860.

The large coloured map of the geographical distribution of heart disease that illustrated my first work in 1875, and which was on a scale of twelve miles to the inch, (the same as the district maps in this edition,) and thirty-nine inches in length

by twenty-nine in breadth, showed at a glance how the distribution of this cause of death was influenced by the configuration of the land and its relation to the prevailing sea winds.

Wherever the conditions named above as necessary for free ventilation of the country by these currents, were present, there invariably are to be found the *low* mortality districts coloured in the different shades of *red;* on the other hand, wherever they are obstructed, as in the pent-up valley-systems of some of the midland counties, or by the precipitous coast cliffs, or by the river-courses trending at right angles to their direction—in fact, wherever free ventilation is effected with difficulty, and the accumulation of residual air favoured, there invariably are to be found the high mortality districts, as indicated by the shades of *blue.*

With regard to the area comprised within the counties of Cumberland and Westmorland, and the Lake District, I will here repeat what I stated in 1868, and first published in 1871.[1] This area is included within the Northern Counties (X.) and the North-Western Counties (VIII.) Divisions.

"The Northern Counties Division has really no inland counties, for Westmorland, which is the most so of the four, has an important sea-inlet penetrating its south-western boundary—the embouchure of the river Kent, which opens into the Bay of Morecambe, an inlet that exercises a powerful influence on the ventilation of the coastal area of Cumberland and Westmorland. The western part of this division may be divided into two parts, the north and south. It is a natural division defined entirely by the watershed. If a line be drawn from a point between Workington and Whitehaven, and made to take a south-easterly direction as far as the south-eastern boundary of West Ward, it will represent sufficiently the elevated ridge of the Cumbrian Hills, which separates the two watersheds of the Cumbrian lake country. This ridge of

[1] p. 49.

towering fells, having an average height of 2,000 feet, acts as a barrier to the north side keeping the direct influence of the sea winds from the valley of the Derwent, and the great valley of the Eden, which is also sheltered by a high ridge of carboniferous limestone rocks to the north-east. On the south side, however, we find all the streamlets and rivers, and the valleys through which they course, running straight to the sea, and exposed in every instance to the full, flushing influences of its winds. From Morecambe Bay to St. Bees Head there is scarcely a valley but what is air-purged every time the wind blows towards it from the Irish Sea. What, therefore, are the coincident facts relative to the mortality from heart disease? On the north and sheltered side there is a *high*, and on the south exposed side a *low*, mortality. The map (heart disease) shows at once the line of demarcation between the two watersheds.

"The sea inlet of the Solway Firth must now be noticed briefly. It will be seen at a glance that it is so placed as to receive, without interruption, the south-westerly winds. At its extreme point, where the rivers Liddel and Line become confluent in Solway Moss, to the south-west of the district of Longtown, the mortality of which (from heart disease) is one of the lowest throughout the division, being only 9·0, the low, flat, alluvial district of Wigton projects seaward, so as to receive a full sweep of the sea winds, and coincident with this is the low mortality, 10·8. Carlisle lies, to a certain extent, inland, in the vale of the Eden, but its mortality of the fifth degree is higher than its position would lead us to expect" (p. 50).

Recapitulation.—The western part (of this division X.) is divided naturally by the high ridge of the Cumbrian Hills. On the north and sheltered side there is a *high* mortality from heart disease, whilst on the southern and exposed side a *low* mortality obtains.

On comparing this mortality and the aspect of the western

part of the division with those of the eastern part of North Riding, we find the direction of the prevailing winds and the flow of the tidal wave the opposite to what takes place on the Cumbrian coast; we find also that the position of the high and low mortality districts is reversed.

The sea inlet of the Solway Firth has a powerful influence on the ventilation of the country to the north-east; and Longtown, which is situated so as to be well flushed by the winds which blow up this inlet, has the lowest mortality in the division.

All the districts in the doubly sheltered valley of the Eden have a high mortality [from heart disease] (p. 51).

Ulverston, the one district in the lake country belonging to the county of Lancaster in the North-Western Division (VIII.), was amongst the southern exposed and low mortality group in 1851–60, consisting of Whitehaven, Bootle, Ulverston, and Kendal.

Such were essential facts relating to heart disease in England and Wales during the ten years 1851–60, and its distribution in the Lake District, Cumberland, Westmorland, and part of Lancashire.

The Geographical Distribution of Cancer among Females in the Divisions (1851–1860).

We have seen, from the description of the map of the divisions illustrating the distribution of cancer, how singularly England and Wales were coloured; that the highest mortality divisions were in the south-east of England, and that this mortality decreased in belts until the extreme westerly and north-westerly divisions were reached, where the lowest mortality was to be found. This arrangement is coincident with the ascent from the preponderating more recent geological formations in the south-east, through the less recent, intermediate, or mesozoic, to the oldest, or palæozoic, in the north-west.

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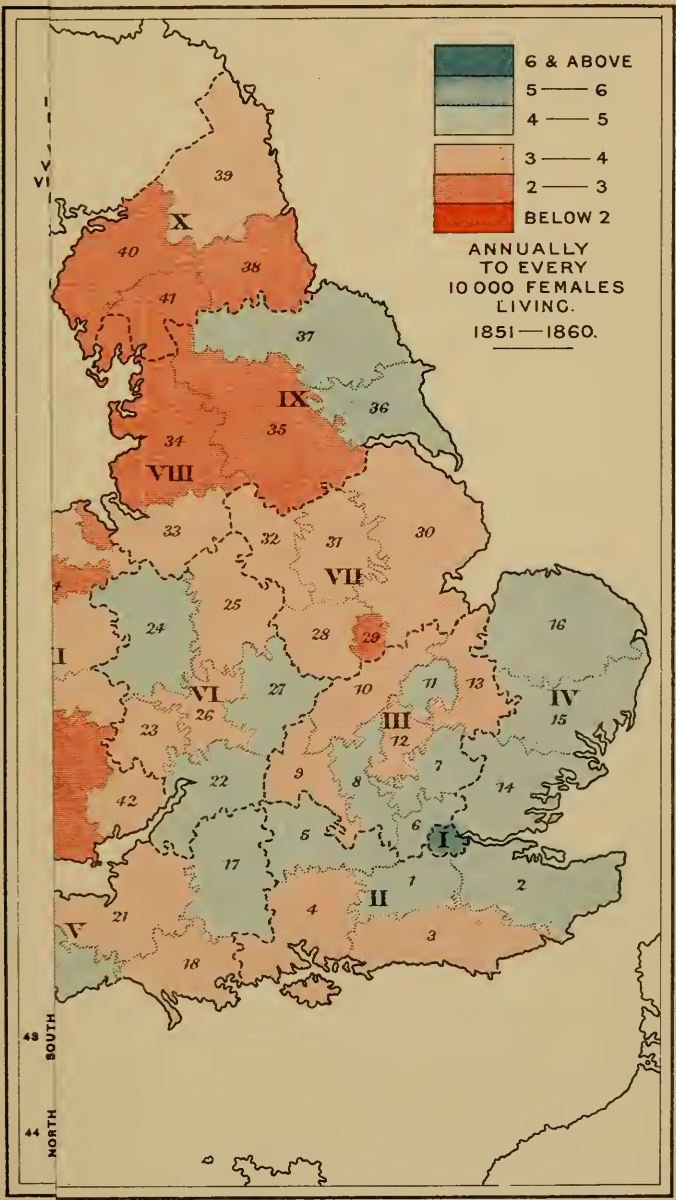

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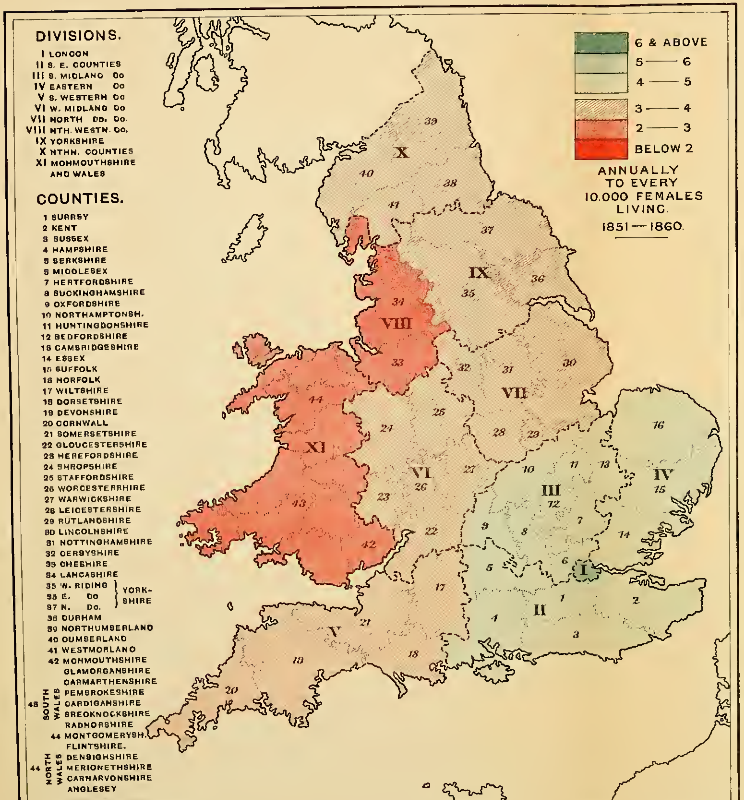
THE GEOGRAPHICAL DISTRIBUTION OF CANCER (FEMALES), 1851-1860,

IN THE REGISTRATION DIVISIONS AND COUNTIES OF ENGLAND AND WALES,

AT "ALL AGES."

DIVISIONS.



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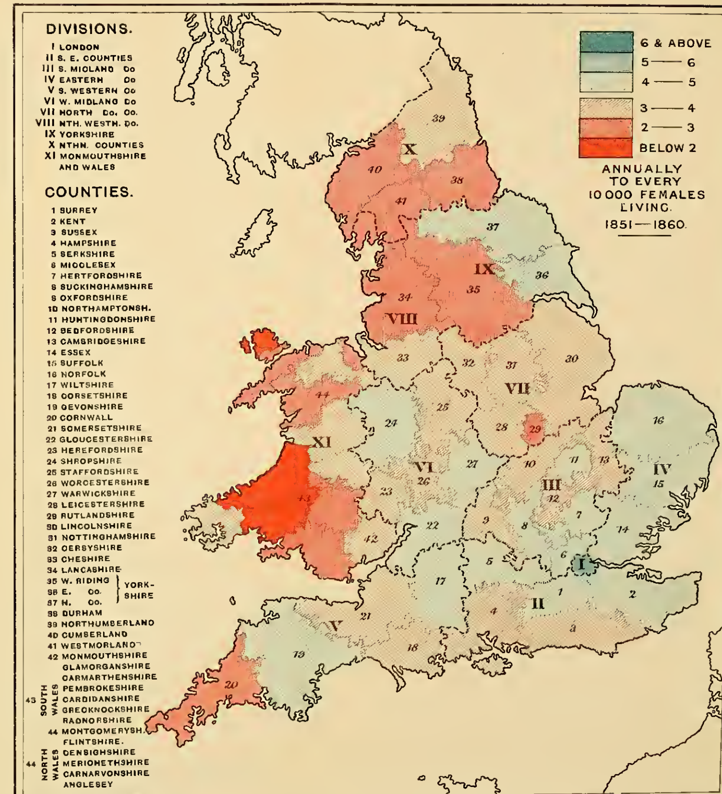

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Cancer in the Counties.

We will now endeavour to show what were the counties that caused this strange banding of the divisions, and what were the dominating causes in the counties themselves.

In the first place, let us take the *south-eastern* high death-rate belt, which includes the following divisions: London (I.), South-Eastern Counties (II.), the South-Midland (III.), and the Eastern Counties (IV.) The counties that make up this group are all characterized, more or less, by rivers, such as the *Thames*, that seasonally flood the districts through which, or near which, they flow. They are also characterized generally by much boulder, and other clays, and other soils of a retentive nature. I stated in my former edition,—

(1). In the counties having a high mortality from cancer we find that the tributaries of the large rivers rise from soft, marly, or other easily disintegrated rocks, and then fall into sheltered valleys, through which the main rivers flow.

(2). These rivers invariably flood their adjacent districts during the rainy season, and have generally their waters coloured by the suspension of alluvial matter. The Thames counties, characterized by their tertiary soil and frequently flooded river, form, as it were, a typical cancer-field (p. 75).

(3). Those counties which are characterized by hard and not easily disintegrated rocks, such as the Welsh Silurian and the great carboniferous range which forms the backbone of the northern counties to the north of the Mersey, and which are fully exposed to the drying influences of the wind, have, coincident with these opposite characters, a low mortality.

The Geographical Distribution of Cancer among Females in the 630 *Registration Districts.*

The large district map of Cancer at once reveals the order of distribution: the student has only to trace the courses of fully-formed rivers of the country from source to sea to

be convinced that, wherever these rivers are known to have facilities, after heavy rains or thaws, for flooding the adjacent area, and for retaining these floods on a clayey, tenacious soil, he is sure to find the districts coloured *blue*, indicating a *high* mortality from this cause; and it will not be long before he has ascertained for himself that the districts through which the higher and earlier tributaries and sources flow are, on the other hand, characterized by *low* mortality. If we take the principal rivers from the river Tweed round by the south and west to the Eden opening into the Solway Firth, we shall find the following, at points where they flood their riparial areas, crowded with *blue*, or high mortality districts: The rivers Tweed, Tyne, Wear, Yorkshire Derwent, Swale, Ouse, Humber, Witham, Welland, Nene, Great Ouse, Wensum, Waveney, Thames, Medway, Stour, Sussex Ouse, Dorset Stour, Devon Axe, Exe, Dart, Way and Tamar, Fal, Tawe, Brue, Avon, Severn, Dovey, Conway, Dee, Derwent (Cumberland), and Eden. All these rivers, in some parts of their courses, flood their banks; and coincident with these seasonal floods we find around them groups of *blue*, or high mortality districts. Where, however, this flooding does not and cannot obtain, there we find the lowest mortality from this cause, even in large towns with many hospitals, and even cancer hospitals, such as at Liverpool, Manchester, Leeds, Bradford, Blackburn. In all these cases the habits of their rivers are totally different from those just named, and, moreover, their sites consist of limestone and other carboniferous formations, which we have pointed out are in themselves antagonistic to the evil effects of floods, even if they did take place on them.

With regard to the area under consideration, in 1868 I pointed out that the Cumberland cancer field followed the course of the river Eden and the valley of the Derwent. The Eden runs through the new red sandstone, and in the neighbourhood of Carlisle the character of the soil is alluvial.

All this, however, will be more fully discussed in the second part of this work.

The Geographical Distribution of Phthisis among Females in the Counties in 1851–1860.

The large district map showing the distribution of phthisis (1851–1860) unmistakably pointed out the significant fact that wherever the prevailing sea winds were capable of exerting their full force there was to be found the *highest* death-rate from this cause. We saw in the map of the divisions that the one showing phthisis was totally opposite to that on which heart disease was plotted; in fact, the one showed that wherever the sea winds blew strongest and exercised their greatest power there was to be found the least number of victims from one kind of disease—heart disease; and that, on the other hand, where these very winds prevailed, there were slain the greatest number of persons suffering from the other kind of disease—phthisis. The maps of these two diseases should therefore be the reverse of each in colouring. And so they are: the rule being, that in the Heart Disease map all the inaccessible and sheltered valleys are coloured *blue*, while in the Phthisis map they are coloured *red;* in heart disease all the districts exposed to the full force of the prevailing winds are coloured *red*, whilst in phthisis they are coloured *blue.*

The Cumbrian and lake areas have been shown to be good examples of the effect of exposure and shelter in the distribution of these two causes of death.

In summing up the facts connected with phthisis as ascertained in 1868–1875, I made the following statements:—

(1). The districts show that coincident with *sheltered* positions is a *low* rate of mortality from *phthisis;* they therefore confirm what was found among the counties and divisions.

(2). The distribution of *phthisis* is almost the reverse of

that of cancer, and differs remarkably from that of *heart disease.*

(3). The warm, protected, fertile, ferruginous red-sandstone tracts of country are remarkable for forming the sites of the most extensive series of *low mortality* groups throughout England.

(4). The high, elevated ridges of non-ferruginous, and unfertile carboniferous formations, and the elevated, hard, unfertile, and non-ferruginous Silurian formations, form the sites of the most extensive series of *high mortality* districts.

(5). The elevated parts mostly exposed to the westerly and north-westerly wind, and to the easterly and south-easterly, are characterized by high mortality.

(6). A sheltered position, a warm, fertile, and ferruginous soil, are coincident, as a rule, throughout England and Wales with *low* mortality from *phthisis.*

Having now given a brief summary of the facts connected with the geographical distribution of the three great groups of diseases—*viz.*, Heart Diseases, Malignant Diseases classed under Cancer (among females), and Pulmonary Tuberculosis under the heading Phthisis (among females)—we are in a position to study each area in minuter detail, and to compare the later with earlier statistics. Moreover, as these three great causes of death have been shown to be influenced by certain grand factors in the climates of the country, we are now in a position to introduce other causes of death, with the view of ascertaining how far they are influenced by the local climates which have been shown to be coincident with such remarkable diverse phenomena in the distribution of heart disease, cancer, and phthisis. With this view, Diseases of the Stomach and Liver, Diseases of the Kidneys, and the Diseases and Accidents incident to Childbirth, have been added.[1]

[1] A few copies of the large coloured maps of the Geographical Distribution of Cancer and Phthisis, among females, in the Districts of England and Wales, published separately, may still be had of Messrs. Swan Sonnenschein & Co., Paternoster Square, London, E.C.

CHAPTER III.

Area Defined—Size—Compared with Others—Natural Boundary System the best—Vagabond parts of Counties and Districts—France more naturally Divided—Isle of Man—Sheadings—Local Government Board and County Councils—Average Size of English, Welsh, Scotch, and Irish Counties—The Boundaries of the Area—*The Coastal Boundary*—Coastal Parishes and Townships—Their Foreshores and Tidal Waters—Sir A. C. Ramsay and Submarine Denudation—Foreshores—Coastal Townships and Parishes—Foreshores and Populations—Length of Coastal Boundary—Foreshores and Sea-inlets—Percentage of Coastal to District Populations—*Inland Boundary*—Districts and Parishes on the Line—Length of—Breadth of Area—Length of Area—Form—Mean Level of Coastal Parishes—Course of the Inland Boundary Line—Mean Height of the Inland Boundary Line along Scotland, Northumberland, Durham, Yorkshire, and Lancashire—Mean Height of the Border District Parishes—Percentage of the Border Population to that of the Border Districts.

THE area we are now studying consists of the counties of Cumberland, Westmorland, and what is known as *The English Lake District*, which includes parts of these counties and the Ulverston district of Lancashire.

The entire area consists of two thousand five hundred and nineteen square miles, and thirty-one statute acres, made up as follows:—

CUMBERLAND ...	970,161	statute acres.
WESTMORLAND ...	500,906	,,
ULVERSTON	141,124	,,
	1,612,191	,,

or 2,519 square miles and 31 statute acres: so that it is one-twentieth the size of England (20·2); nearly one-third that

of Wales (2·9); and one-twelfth that of Scotland (12·0). The areas of these three parts of Great Britain being as follows :—

	Sq. Miles.		Statute Acres.
England	50,933	and	178
Wales	7,377	„	543
Scotland	30,417	„	98

The area is about equal to that of two average English counties, which vary in size from $148\frac{1}{4}$ square miles, as in Rutland, to the 6,066 square miles of Yorkshire. The history of the sizes, forms, and boundaries of counties would be a curious one indeed.

There is no country, either great or small, whose rulers have, for governmental or other purposes, divided it according to the natural boundary system. If we take England as an instance, we find in it very few counties that are even approximately defined by natural boundaries. Yorkshire and Northamptonshire approach nearest to this common-sense mode of regulating county boundaries; but when we examine the six hundred and thirty districts into which England and Wales are divided for registration purposes, then we are at once brought face to face with the utmost confusion, which, in many instances, is made worse confounded by the fact that many of these artificially formed poor-law or registration districts are not self-contained, but are so constituted that fragments are found in the centres of other districts; a similar state of things also obtains among the counties: a vagabond bit of Gloucestershire may be found in Warwickshire or Northamptonshire, or if we go to Scotland we shall find a bit of Stirlingshire in the midst of Clackmannan and another in Perthshire, as if they had been exiled.

In France a much more natural plan has been adopted, the river system of that country seemingly having formed the basis of departmental boundary lines. Even in the Isle of Man the *sheading*, into six of which the island is divided,

had once natural boundaries. Each sheading had its central river, the catchment basin of which occupied the higher portion of the parishes comprehended within its boundaries. It seems highly probable that in the *original* division of the island, the chief rivers and other water courses, their water-partings and their catchment basins, were taken as guides by its early invaders, the Norwegians, which at all events is evidence of their possessing at least some common sense, a mental qualification that does not seem to have been possessed by either the original designers of the Poor Law districts, which are now used for registration and sanitary purposes, or by the more recent Local Government Board officials who have attempted to rectify the ancient blunders of their predecessors. County Councils have now a golden opportunity of doing some service to science in this matter.

The student of medical geography must expect to meet with plenty of difficulties in carrying out his investigations, and among the first will be the artificial mode of dividing the country; but as it cannot now be altered as regards the statistics already collected, the difficulty must be met, and made the best of, ever remembering that few evils are unmitigated.

The average size of the counties varies in Great Britain and Ireland :—

Thus the	40 English	counties	average	1,273	sq. miles.
,,	12 Welsh	,,	,,	614	,,
,,	33 Scotch	,,	,,	921	,,
,,	32 Irish	,,	,,	992	,,

The English counties ranging from Rutland, with an area of only 148 square miles, to Yorkshire with one of 6,066 square miles. The registration districts vary even more in size one from another; but it is not worth while to give details as in the course of this work there will be frequent opportunities of discussing the incongruities in their form, size, and boundaries.

The Boundaries of the Area.

From what has already been said on the effect of our coast line and its sea inlets on local climates and diseases, it will be expected that great stress would be laid upon this natural boundary of Great Britain: it is the boundary that has the hardihood to defy the Local Government Board, and it will not be meddled with; it is therefore the one to be depended on, whether we are studying the country as a whole or the different areas into which I have divided it for medico-geographical purposes.

The Cumberland, Westmorland, and English Lake district area has two boundaries, one the coastal entirely natural, and the other inland, irregular, and more or less artificial. The boundaries meet at the Solway Firth in the north and at Morecambe Bay in the south, and enclose a somewhat oval, or an irregularly rhomboidal area. Taking the course of the sun we will trace first the *Coastal Boundary* from the north-east coast of Morecambe Bay to the south coast of Solway Firth.

Along this course in the same order there are the following *coastal* registration districts:—

Kendal (Westmorland), *Ulverstone* (Lancashire), *Bootle, Whitehaven, Cockermouth, Wigton,* and *Carlisle* (Cumberland), the coastal boundaries of which form that of the area: this fact alone, however, helps us but little; we want more detail with regard to the *foreshores, tidal waters,* and the *position* of the *populations,* with regard to them, and this can be easily obtained by ascertaining the facts connected with the coastal boundaries of the coastal parishes or townships which skirt the districts given above.

The Coastal Parishes and Townships: their Foreshores and Tidal Waters.

There is a wide difference between the precipitous steep-to coast-line of cliffs, and the sloping foreshore. The latter

only in an extreme form, however, is to be found skirting this area, and prevailing throughout its whole extent with the exception of a short distance at the foot of St. Bees Head.

When the difference between the effects of a precipitous and a shelving coast comes to be studied, the interest in these physical features cannot fail to increase.

Whether we view from a height the gradual slope of a series of hill-tops sea-ward, or the wide expanse of the sloping shore on the western coast of Cumberland, we are conscious of having before us the work of submarine denudation. Ramsay showed how regularly the tableland of Wales had been worn down seawards by submarine denudation, as indicated by the generally lessened height of the land towards the sea; although now disguised by the intersecting work of sub-aërial denudation, in the form of river channels; this sloping towards the sea of plains of marine denudation, as first described by Sir A. C. Ramsay, in his "Physical Geology and Geography of Great Britain," p. 496, must be taken into account with the effect of physical configuration on local climates as influenced by the powerful winds.

As a rule we know that a steep-to or precipitous coast generally rises out of deep water, whereas a low coast generally stretches far out until it is covered by a shallow depth of the sea at some distance from high water mark. The *foreshore* is in fact that sloping part of the sea-shore which is exposed between the tidal low and high water marks—the greatest width occurring during spring tides, at which time the tides gain their highest and lowest points. Foreshores generally are extensive and very important at the great inlets into this country, two of which are enjoyed by the lake area; at these inlets the foreshores are of great size, and their gradual slope over wide reaches, in the trend of prevailing winds, facilitates the passage of these currents inland, where their influence is felt far up into the heart of the country, provided the initial slope from the sea is preserved.

The coastal boundary consists of the following coastal parishes included in the registration districts which extend to the sea. Beginning with KENDAL, the parishes range themselves in the following order around the coast: *Beetham, Haverbrach, Heversham* and *Milnthorpe, Levens, Meathop* and *Ulpha*, and *Witherslack*. The *Kendal Coastal Parishes* have a population of 5,057; 373 statute acres of tidal water, and 4,585 statute acres of foreshore.

The coastal parishes of ULVERSTONE are *East Broughton, Lower Allithwaite, Lower Holker, West Plain* (reclaimed), *Out Marsh* (reclaimed), *Barrow-in-Furness, Dalton-in-Furness, Egton with Newland, Ulverston, Urswick, Aldingham*, and *Dalton-in-Furness*, which have a total population of 77,362, and 1,383 statute acres of tidal water, and 51,403 statute acres of foreshore.

BOOTLE is skirted by the following coastal parishes: *Millom, Whicham, Whitbeck, Bootle, Waberthwaite, Muncaster*, and *Drigg*, which have a total population of 10,465; 1189 statute acres of tidal water, and 9,271 statute acres of foreshore.

WHITEHAVEN, although it has an extensive sea coast, has no great width of foreshore, and it is within this district that the highest sea-cliff occurs, namely St. Bees Head, in the parishes of Sandwith and Rottington, which is 323 feet above ordnance datum. The coastal parishes are *Gosforth, Ponsonby, St. Bridget Beckermet, Lowside Quarter, St. Bees, Rottington, Sandwith, Whitehaven, Parton*, and *Harrington;* and have a total population of 28,768; 7 statute acres of tidal water, and 2,015 statute acres of foreshore.

COCKERMOUTH has arranged along its coast, *Workington, Seaton, Flimby, Cross Canonby* with *Mary Port, Ellenborough* and *Ewanrigg, Oughterside*, and *Allerby*, which have a total population of 31,037, and enjoy 55 statute acres of tidal water, and 2,230 statute acres of foreshore.

WIGTON enjoys the commencement of the Solway Firth, and its wide sands and tidal waves. The parishes exposed

to their influences are *Hayton* and *Mealo*, *West Newton* and *Allonby*, *Holme St. Cuthbert*, *Low Holme*, *Holme East Waver*, *Kirkbride*, *Aikton*, and *Bowness;* the whole population of which amounted in 1881 to 5,743, enjoying a tidal water of 1,409 statute acres, and a foreshore of 18,657 statute acres.

Carlisle reaches to the Solway Firth by means of *Rockliffe*, *Beaumont*, and *Burgh-by-Sands* to the 4,211 statute acres of foreshore, which it enjoys, and, in addition, *Grinsdale* and *Kirk-Andrews-upon-Eden* enable it to have 20 statute acres more of tidal water besides the 646 statute acres supplied by the foreshore. The population is 2,114.

Longtown is the last district in this area enjoying foreshore and tidal waters, of which it has 261 statute acres of the former, and 77 statute acres of the latter through the coast along *Nether Quarter*, and *Arthuret with Longtown*. The population was 2,980 at the census of 1881, the date of those of the other coastal parishes.

The facts relating to the proportion of foreshore area to district area, and of the coastal population to that of the districts, are epitomized in the following Table:—

TABLE I.

Coastal Districts.	Populations, 1881.		Per cent.	Areas.		Per cent.
	Coastal Parishes.	Entire District.		Foreshores.	Districts.	
Kendal	5,057	41,574	12·1	4,585	196,267	2·3
Ulverstone . . .	77,362	90,940	85·0	51,403	152,091	33·7
Bootle	10,465	12,225	85·6	9,271	91,301	10·1
Whitehaven . . .	28,768	59,292	48·5	2,015	90,715	2·2
Cockermouth . . .	31,037	56,789	54·6	2,230	170,155	1·5
Wigton	5,743	23,440	24·5	18,657	137,647	13·5
Carlisle	2,114	52,762	4·0	4,211	69.164	6·0
Longtown	2,980	7,711	38·6	261	88,245	·3
	163,526	344,733	47·4	92,633	995,585	9·3

Coastal Boundary—its Length.

The above Census and Ordnance Survey figures give us the following facts : (1) that the *coastal boundary* of the Cumbrian and Lake area consists of a series of coastal parishes or townships, extending from *Beetham* in the Kendal district, Westmorland, through *Ulverston*, in Lancashire, to *Longtown*, in Cumberland—a length of about 126 miles ; the line simply passing through the parishes approximately parallel to the coast without following its sinuosities ; of this coast Cumberland shared 76 miles, Lancashire 24, and Westmorland 24. Omitting the sands at the mouths of the rivers Kent, Levens, Duddon, Esk, and Solway Firth, the ordinary foreshore of the sea coast has only a mean width of about a quarter of a mile ; but this is an enormous advantage, especially as in this case it is the fringe of a sloping inland country. The great inlets, just named, with their extensive Cartmell and Ulverston sands, Mort Bank and Flat, the Duddon sands, the Drigg sands of the Esk, the Moricambe, Cadurnock sands, and middle bank of the Solway Firth, are, however, the great physical features which give character to the local climates of this large area.

(2). That the amount of foreshore enjoyed by each of the coastal districts, not included in the area of the parishes and townships, varies from 0·3 per cent. in the case of Longtown, to the 33·7 per cent. in that of Ulverston, the mean percentage for the eight coastal districts being 9·3 per cent., and (3) the important fact that along these 126 miles of coastal country there stretch, one after another, a series of townships and parishes, which at the census of 1881 contained 163,526 males and females, or 47·4 per cent. of the entire population of the eight districts. The eight coastal districts, already named, had in 1881 a population of 344,733, of which 163,526 lived in towns, villages, and parishes that immediately abutted on the seashore.

Now in geographizing disease, and in calculating the effect of local climates on communities, such facts cannot be ignored. At the very threshold of the investigation they must be taken into account, and made familiar to our work. The 57 towns and villages which stretch along the coast line contain 47·4 per cent. of the population of the 224 parishes constituting the eight coastal districts.

The Inland Boundary.

The Inland Boundary of the area begins where the coastal ends, namely on the north-west limit of Longtown, which separates this district from the Scotch counties of Dumfries and Roxburgh; and then extends along the north-east limits of Longtown, Brampton, and part of Alston, which separate these districts from Northumberland, and lastly along the eastern and southern limits of East Ward, and the eastern boundary of Kendal, which separates this area from Yorkshire, and the southern boundary of Kendal, where that district abuts on Lancashire.

Following the plan adopted in tracing the coastal boundary line, we now give, in consecutive order, the names of the parishes and townships which form the inland boundary line.

In the LONGTOWN district are *Moat*, *Nichol-Forest*, *Bewcastle*; in BRAMPTON, *Arkerton*, *Kingwater*, *Waterhead*, *Upper Denton*, *Nether Denton*, *Farlam*, *Midgeholme*; in PENRITH, *Croglin*; in ALSTON, *Alston*; in EAST WARD, *Dufton*, *Appleby*, *St. Michael*, or *Bongate*, *Warcop*, *Stainmore*, *Kaber*, *Winton*, *Hartley*, *Nateby*, *Mallerstang*, *Ravenstonedale*, *Orton*; in KENDAL, *Dillicar*, *Firbank*, *Killington*, *Middleton*, *Barton*, *Casterton*, *Kirkby Lonsdale*, *Hutton-Roof*, and *Burton-in-Kendal*, to *Beetham*.

The populations of the above parishes which skirt the *inland boundary line* are given in the following Table II., with the proportions they bear to the entire populations of the districts containing them:—

TABLE II.

	Populations.		Per cent.
	of Inland Boundary Parishes.	of Entire Districts.	
Longtown . . .	1,702	7,711	22·0
Brampton . . .	3,178	10,565	30·0
Penrith	251	23,242	1·0
Alston	4,621	4,621	100·0
East Ward . . .	7,104	14,515	48·9
Kendal	4,367	41,574	10·5
	21,223	102,228	20·7

Length of Inland Boundary Line.

The inland boundary line of this area shares the county boundaries of Dumfries and Roxburgh along the north-west of Longtown for fifteen miles; on the north-eastern and easterly borders of Longtown, Brampton, and parts of Penrith and Alston lie forty-eight miles of the Northumberland boundary, which along the east side of Alston is succeeded by a part of the western boundary of Durham, to the south of which, along the eastern and southerly sides of the East Ward and Kendal districts, Westmorland lies next to Yorkshire for fifty-six miles; and then along the south side of Kendal Westmorland shares fifteen miles of the Lancashire county boundary from the east end of Casterton to Beetham, whence the coastal boundary started. The entire length of this boundary is about 143 miles, so that, roughly given, the circuit of the area would be about 269 miles. The widest part of the area is in a line due east from St. Bees Head to the eastern boundary of East Ward in Westmorland, and measures fifty-nine and a half miles; the longest from north to south, namely from the extreme north of Bewcastle parish, in Longtown, to the most southerly point of the Isle of Walney,

Hilpsford Scar, belonging to the Ulverston district, the area measures eighty-two miles in a slightly N.E. and S.W. direction. The shape of the area is thus roughly rhomboidal, not unlike some of the blocks of Lower Silurian rocks or Skiddaw slates. The coastal boundary line must be taken as at the mean sea level, and that of the margin of parishes a little above ordnance datum, or 18·0 ft.: the mean height of the marginal parishes of each coastal district being as follows:—Kendal 67·5 ft., Ulverston 80·6 ft., Bootle 56·8 ft., Whitehaven 139·0 ft., Cockermouth 96·4 ft., Wigton 25·0 ft., Carlisle 25·0 ft., Longtown 25·0 ft., the mean for the whole being 73·3 ft.

Now along the inland boundary we have a very different state of things, but equally important and interesting.

The natural inland boundary line of this area and the artificial one between the registration counties of Northumberland, Durham, Yorkshire, and part of Lancashire, and the counties of Cumberland, Westmorland, and part of Lancashire, are not identical, the former throughout its course lying at varying distances to the east and south-east; but we shall not dwell upon the details here as they will be discussed later on when the physical geography of the inland districts are considered.[1]

The north-west boundary of Longtown is so far natural, inasmuch as it follows the course of the river Liddel and one of its sources, Kershope river, which rises on the west side of Dove Crags, nearly opposite to one of the sources of the North Tyne on the east. Near this spot, at the foot of the same crags, the Black Line river springs, seen in the district map. This part of the boundary is flanked to the north-east by the elevated water-parting which separates the basin of the North Tyne from that of the Line on the west; in fact, the north-east boundary of Longtown lies on very high ground. The north-east and south-east boundary of Brampton is coin-

[1] See description of "The Contour Map."

cident with the course of the source of the river Irthing, which is seen joining the river Eden near the north-east boundary line of Carlisle district. The Irthing rises near Christenbury Crags, and is separated by the water-parting from the catchment basin of the North Tyne. From the point at which the Irthing turns to the south-west to cross Brampton (and join the Eden), near Upper Denton, the line runs along high ground, namely, Geltsdale Forest, which separates the Vale of Eden from the basin of the South Tyne; and here, instead of pursuing its natural course along the ridge, it is made to cross the valley in which the sources of the South Tyne run, along the courses of the Gildersdale and Aleburns, after which it mounts the high ground and runs southward along the water-parting between the source of the South Tyne and the river Wear; in doing which it embraces the district of Alston from Penrith to East Ward. In the latter district, by some means it is forced over the water-parting into the valley of the sources of the river Tees, but, as if out of its element, it passes up to the high ground of Lune Forest and Stainmoor Forest, where it is seen performing once more its natural function by separating the eastern waters of the Swale from the western waters of the Eden, and the sources of the Eden from those of the Ure or Yore. So far, with the exception of looping in Alston, which geographically belongs to the catchment basin of the Tyne in Northumberland, the inland boundary line has, to a certain extent, taken a natural course, that of dividing the catchment basins of the east and west from each other. On the north-west side of Longtown we found the rivers Liddel and Kershope forming a portion of the boundary; but it should be remarked at once that, however apparently fit a river may be to form a boundary, it is far from being so: the river, it must be remembered, is part and parcel of what it divides. On leaving the water-parting which separates Yoredale and the river Yore or Ure from Ravenstonedale and the River Eden, it turns back to

the north-west to get into the deep valley between Langdale and Houghill Fells, until it reaches the river Lune, when it turns sharply south to run along its left bank as far as the entrance of the tributary Rother; it then runs along the left bank of this tributary as far as Dent Dale, where it is made to mount the high water-parting between the Dent Dale and the valley of the Lune, from which, however, it precipitately descends to cut the Lune in two south of Kirkby Lonsdale in a westerly direction over Hutton Crags, south of Burton, to end at the southern boundary of the Beetham parish in the district of Kendal at the mouth of the river Kent in Morecambe Bay.

The Course of the Inland Boundary Line.

If we trace the artificial line between our area and Scotland, and England we shall find the following facts, showing the difference between the heights of the artificial and natural boundaries. In this case the two lines, although they do not coincide, are not so widely separated as to cause inconvenience to the medical geographer. The natural boundary is the one that we have to reckon with and study, for it should be nature's party wall between two or more areas. The artificial boundary line, when it deviates from the natural, seems only to have been made to do so for the purpose of sharpening our wits in devising means for counteracting its evil effects both in science and politics.

As usual, the natural inland boundary line of this area is of great interest and importance. At present, however, I shall content myself with the bare facts connected with the levels, as this subject will be again more fully discussed in the chapter devoted to the physical geography and geology of the area.

The mean heights of the marginal parishes skirting the inland boundary are as follows for each district:—Longtown, 1,013 ft.; Brampton, 820 ft.; Penrith, 1,129 ft.; Alston,

1,500 ft.; East Ward, 1,228 ft.; and Kendal, 625 ft. The mean for the whole being 1,052 ft.

The Course of the Inland Natural Boundary.[1]

The inland natural boundary of this area is, in fact, the northern part of the Pennine Chain, which stretches from Derbyshire to the Scotch border, and is one of the most powerful factors in the British climates that we shall have to deal with; it is well, therefore, to define it at the outset, so as to understand its influence on the area under discussion.

Longtown.—It commences at the Scotch border, in longitude 2°40′ 40″ W., above the source of the Kershope Burn; it soon joins the county boundary, and gives rise to the sources of the river Line; but at the point where the river Irthing rises it leaves the boundary and runs in an easterly direction, so as to embrace the Northumbrian sources of this river across Paddaburn Moor, where, at the source of the Padda Burn, it is at least a mile and a half from the county boundary, in a north-easterly direction, and is opposite Irthing Head, where the district boundary between Longtown and Brampton begins at the county boundary.

During this course to the east of Longtown its mean height is 1,503·7 feet, and its length eleven miles.

Brampton.—From this point it passes in an easterly direction to Green Moor, where it is about 2¼ miles from the county boundary; it then turns to the S.W. over to Great Watch Hill, and continues almost parallel to the county boundary as far as Thirlwall Common, crossing in Nether Denton parish the county boundary to enter the Brampton district in a S.W. direction until it reaches Kelky Fell (1,241 ft.), when it is 5¼ miles to the W. of the county boundary. It then turns to the S.E. to embrace the *Old-Water* and *New-Water* sources of the river *Gelt*, which joins the river *Irthing*, at *Rye Close*, just above where it enters the

[1] See "Contour Map," where it is shown by a red line.

river Eden; from *Kelky Fell* it proceeds in a S.E. direction to within three-quarters of a mile S.E. of *Cold Fell* (2,039 ft.) where it joins the county boundary, near the source of the *Black* Burn, a tributary of the *South Tyne*; it is then coincident with the county boundary as far as *Butt Hill* (1,500 ft).

During this course in relation to the *Brampton* district, its mean height amounts to 1,054 ft., and its length thirty-one miles.

Penrith.—At Butt Hill the boundary line between Brampton and Penrith begins, and from this point the natural boundary line is coincident with the county boundary until it reaches the *Knar Burn*, in the parish of Knaresdale (2,071 ft.); it then suddenly leaves the latter, and taking a southerly direction, proceeds to *Melmerby Fell*, and during its course gives rise to *Croglin Water* and *Raven-beck*, tributaries of the river *Eden*. It then continues to *Melmerby High Scar* (2,247 ft.), when it runs south-eastwards to the county boundary, which it crosses to the S.E. of *Cross Fell* (2,930 ft.), and enters *East Ward* district. During its course across the *Penrith* district it not only cuts off the eastern part of it, but the whole of *Alston* district, which, in fact, does not belong to Cumberland or this area at all; for it is contained in the eastern watershed of the Pennine Chain, and gives rise to the early sources of the *South Tyne*, which are separated from those of the *Eden* by the water-parting of the natural inland boundary.

During its course of 12½ miles through Penrith it has a mean height of 2,254 ft.

East Ward.—After leaving the point near *Cross Fell* it crosses the county boundary and takes a S.E. course to the extreme S.E. boundary of *East Ward*. When between *Stainmore Forest* and *Bowes Moor* for a short distance it runs coincidently with the county boundary of Westmorland, having the sources of the river *Tees* on its N.E. flank. At *Beldoo Hill* (1,565 ft.) it leaves the county boundary and crosses over *Mondy Mia* and *Cansey Moss* (1,649 ft.), and passes between

the sources of the river *Belah* on its way to the river *Eden*, and those of the river *Swale* on its eastern flank (Yorkshire); it then follows the course of the county boundary until it reaches the sources of the *Hell Gill Beck*, after which it turns to the W., and passes between those of the rivers *Eden* and *Ure*, or *Yore*, along the *col* between them at a height of 1,189 ft., when it finally leaves the county boundary and the area altogether. Whilst within *East Ward* it attains a mean height of 1,835 ft. and stretches over thirty-eight miles.

KENDAL.—We have now to trace it from the last point at some considerable distance from the *Kendal* district outside the area. Immediately on leaving the county boundary it proceeds in a S. by E. direction to *Pennegent* (2,250 ft.), having along its northern portion the sources of the river *Lune*, and along the southern those of river *Ribble*, all of which are derived from its western flank, between it and the county boundary of Westmorland, which here serves as the district boundary of *Kendal*. The average distance between the county and natural boundary being in this part of the latter's course about 9·9 miles, taken at ten different points. The mean height of the Pennine Chain along this part of its course amounted to 1,829 ft., through the distance of twenty miles.

The above mean heights and lengths of water-parting may be arranged as follows:—

Districts.	Mean Heights. Feet.	Lengths. Miles.
LONGTOWN	1,503	11
BRAMPTON	1,054	31
PENRITH	2,254	12½
EAST WARD	1,835	38
KENDAL	1,829	20
	Mean height 1695	Total length 112½

It will be observed that the extreme eastern district *Alston*

has no share whatever in the natural boundary—in fact, it seems to remind us of the early raids made by early Cumbrian kings over their border in search of plunder from their neighbours and enemies. Alston has been filched from Northumberland or Durham, or from both, but when and by whom I am not prepared to say—the fact, however, remains.

As we proceed we shall find how necessary it is to preserve in our minds clear ideas as to heights and geological structure; for step by step we find these natural boundaries intimately associated at every turn with differences in climate.

The Population of the Border Parishes, and their Proportion to those of the Border Districts.

We found at p. 47, Table I., that the population of the coastal parishes amounted to 47·4 per cent. of that of the coastal districts of which they formed the margin. We have now to compare this with the inland and upland boundary margin:—

Districts.	Population, 1881.	Border Line. Population.	Per cent.
Longtown	7,711	1,702	22·0
Brampton	10,565	3,178	30·0
Penrith	23,242	251	1·0
Alston	4,621	4,621	100·0
East Ward	14,515	7,104	48·9
Kendal	41,574	4,367	10·7
	102,228	21,223	20·7

It may be stated generally, although reference will be again made to the subject, that while the *coastal* districts and parishes in 1881 showed an increased population when compared with 1871, the upland, inland, and border line districts and parishes were marked by a decrease—out of the eight coastal, seven in 1881 had increased populations, whereas, out of the eight upland and border districts, seven out of the eight had decreased.

CHAPTER IV.

The Great Transverse Ridge—Hippocrates and Water-partings—Direction of Central Water-parting — Course described on District Map — Western End of Ridge—Central Portion—Eastern End of Ridge—Eiffel Tower—The English Lake Area—Boundaries of Lake Districts—Inland Boundary Line of Lake District—The Contour Map—Coastal Boundary Line—Hydrography of the Area—Rivers and Aspects—Inland Waters—Lakes—Their Areas—Lake Parishes—Percentage of Lake Populations—Free and Imprisoned Waters contrasted—Cascades, Torrents, and Lakes—Their Life-giving Waters—Floods—Their Impurity and Power for Evil—Southey's Lines on Lodore—Floods and Local Climates—Effect on Health.

THE altitudes of the great longitudinal wall bounding this area on the east, and its general strike north and south, having been discussed, we must now direct our attention to another equally important physical feature of the Lake District,—the great transverse ridge, which, as a stupendous rampart, strikes across this area from east to west, or at right angles to the great backbone of Britain, part of which I have endeavoured to describe in the last chapter—This lofty wall, so far as the local climates of Cumberland, Westmorland, and the Lake District are concerned, will be found to exert a more remarkable influence on the health of the districts that radiate from its water-parting ridge than even the northern portion of the Pennine chain.

The Great Transverse Mountain Ridge, or Central Water-parting and its Branches.—Hippocrates (460–357 B.C.) was the first to recognise the importance of studying water-partings and water-sheds in relation to local climates and diseases; he well knew how the prevailing winds were affected by the one, and the sunshine by the other; he also pointed out that these features, according to their position, were

capable of causing a difference in the climates of two places only a furlong apart.[1]

The great central water-parting of this district is remarkable not only on account of its great influence on the local climates of the districts on its northern and southern sides, but for its length, height, direction, and geological structure, all of which have most interesting histories, which, however, we must leave for the present.

This central water-parting stretches right across the Lake District from west to east; and, without reckoning the curves which occur during its course, its length in a straight line from Dent Hill to Wasdale Pike, is about 32 miles; the width of the district at this point, namely from St. Bees Head on the west, to the extreme eastern boundary of West Ward, being about 45 miles, so that the ridge occupies all but 13 miles of a line extending through the most central and widest part of the Lake District. Either of the accompanying maps will enable the reader to trace this water-parting if the following instructions are attended to.

First, find Ennerdale water in the *Whitehaven district*, this lake is 369 ft. above sea level; on the east is seen its affluent (the river Liza), which has its source at Green Gable (2,500 ft.), and on the west its effluent (the river Ehen), which at Cleator bends suddenly to the south around the western end of the central water-parting, which culminates in Dent Hill (1,130 ft.), whose position in the map corresponds with the T in WHITEHAVEN: the water-parting then takes a north-easterly direction, but to the south of the river Ehen and Ennerdale water to Grike (1,596 ft.), and then in a south-easterly direction over Iron Crag (2,071 ft.) to Cawfell (2,188 ft.), which mountain lies immediately to the south of the south-east end of Ennerdale Water, at a distance of nearly two miles, pro-

1 *ἢν καὶ στάδιον τὸ μεταξὺ ᾖν.* "Airs, Waters, and Places."—Littré, vol. ii. p. 22. A *stadium* contains 606 ft. 9 in., or 53 ft. 3 in. less than a *furlong* (660 ft. 0 in.), and is about an eighth of a mile.

ceeding east it passes over Haycock (2,619 ft.), then to the north-east over the high land (2,746 ft.) from which some sources of the river Liza are derived, and on to Pillar (2,927 ft.), then easterly to Looking Stead (2,058 ft.), where it turns to the south reaching Kirk Fell, and thence on to Great Gable (2,949 ft.), and above Styhead (2,500 ft.), near the point where, in the map, the three districts *Cockermouth*, *Whitehaven*, and *Bootle* are seen to meet; still pursuing a south-easterly course it passes over Great End (2,984 ft.), which lies on the north-east boundary of Bootle; from Great End it follows the north-east boundary line of *Bootle* until it reaches the county boundary, on which it lies as far as Seat Sandal, through the point at which the three districts meet, to the height above Angle Tarn, where the Bootle boundary line joins that of the county (2,500 ft.), and Bowfell (2,960 ft.); then passing to the north-east the water-parting crosses over Rossett Crag (2,106 ft.), the Black Crags (1,922 ft.), after which Thunacar (2,351 ft.) is reached, Sergeant Man (2,414 ft.), Calf Crag (1,762 ft.), and to Steel Fell (1,811 ft.), below which it crosses the road from Windermere to Keswick, at the pass of Dunmail Raise (783 ft.), and lastly to the summit of Seat Sandal (2,416 ft.); at this point the main water-parting leaves the county boundary and follows the northern boundary line of the *Kendal* district through Fairfield (2,863 ft.), Hart Crag (2,698 ft.), at the head of Deepdale (2,863 ft.), Rydal Head (2,698 ft.), to Little Hart Crag (2,091 ft.), the Red Screes (2,541 ft.), and Kirkstone Pass (1,450 ft.), at which point the line suddenly turns to the north-east, passing over John Bell's Banner (2,474 ft.), Stony Cove (2,502 ft.), Caudale Moor (2,214 ft.), High Street (2,214 ft.), where the old Roman Road runs along it, through Harter Fell (2,500 ft.), over Tarn Crag (2,176 ft.), Harrop (1,963) ft., where the water-parting leaves the district boundary line to the south of Hawes Water (694 ft.), over the Shap Fells to the east, and terminates at Wasdale Pike (1,853 ft.). Such are the

ups and downs of this wonderful barrier, that stretches across the Lake District from east to west, for more than 31 miles, separating the northern from the southern lakes, and creating differences in the local climates of the two areas, which are made more evident by the death-rates from certain causes than by the delicate instruments of the meteorologist.

The height of this natural wall may be realized by the following summary of the facts just detailed. The water-parting is divisible into three parts :—

1. The *Western End*, which extends from Dent Hill through the middle of the *Whitehaven* District to the point where the three districts of *Cockermouth*, *Whitehaven*, and *Bootle* meet, has a mean height of 2,139 ft.

2. *The Central Part* then starts from the latter point and follows the boundary line of the north-east of Bootle, and then along the county line, which is also the northern district boundary line of the *Kendal* District, to Harrop Pike, where the line leaves this combined boundary line : the mean height of this central portion amounts to 2,323 ft., and—

3. The *Eastern Portion*, from Harrop Pike to Wasdale Pike, over the Shap Fells to the north of that on the Kendal boundary. This, the shortest division, has a mean height of 1,878 feet. The mean height of the three divisions amounting to 2,244 feet, which exceeds that of two Eiffel Towers piled one on the other (1,968 feet), by 276 feet. This tower all of my readers have heard of and many have seen, is 984 feet in height, and proves a good unit for comparison. Curiously enough, whilst using this structure to give an idea of this great Lake Wall, I am reminded that the volcanic materials of lava and ash, of which it is composed, have been said to present all the characteristics of the streams which flowed from the extinct volcanoes of the Eifel.

For the use of those who may visit this grand and interesting country, lists of the heights described will be given at the end of the work, and other details connected with physical

features which cannot conveniently be given here or elsewhere.

We may now turn our attention to the boundaries of the English Lake District.

The English Lake District; its Boundaries and Registration Districts.

The English Lake District is comprehended within the common boundary of the seven Registration Districts; four in Cumberland, namely, *Bootle*, *Whitehaven*, *Cockermouth*, and *Penrith;* two in Westmorland, *West Ward* and *Kendal;* and one in Lancashire, *Ulverston.* These seven districts roughly radiate from a circular area, the centre of which is on Coldbarrow Fell to the south of Blea Tarn at a point in the coloured maps corresponding to the top of the left-hand limb of the letter H in COCKERMOUTH. From the extreme south-west corner of the *Penrith* district, where the county boundary between Cumberland and Westmorland turns suddenly at right angles to the south, (at Stybarrow Dodd, 2,756 feet), and passes through the two r's in the word *Thirlmere*, draw a straight line to the north-east boundary of Bootle, which is part of the great central water-parting at the point where it divides the sources of the Long-strath Beck, one of the affluents of Derwentwater, on the north, from Lingmell Beck, the affluent of Wast Water on the south, seen also in the north-east of *Bootle* district. The sources of these two rivers, which are well seen, although not named, on the maps, have between them Great End (2,984 feet), which forms part of the great central water-parting. The distance between the north-east and south-west points is $9\frac{1}{2}$ miles, the length of the radius of a circle drawn around the centre of this line would therefore be $4\frac{3}{4}$ miles and found as described on Coldbarrow Fell. Within this circle lie parts of six out of the seven districts, the centre being $4\frac{3}{4}$

miles from *Penrith* and *Bootle* respectively; 3½ from *West Ward;* 2 miles from *Kendal* district; 4½ from *Whitehaven;* and 6½ miles from *Ulverston,* which is only just outside the ring, being separated from the Cumberland and Westmorland districts by *Kendal* and *Bootle.*

The disposition of these districts around the described centre has its origin evidently in the configuration of the land, which, as will be further shown, has given the direction to the courses of the rivers and the lakes they feed.

The Inland Boundary Line of the Lake District is shaded in the map, and is seen to separate *Cockermouth* from Wigton; *Penrith* from Wigton, Carlisle, Brampton. (Haltwhistle in Northumberland), Alston and East Ward; *West Ward* from East Ward; and *Kendal* from East Ward (Jedburgh in the West Riding of Yorkshire and Lancaster).

The Coastal Boundary Line is made up of the north-west boundaries of *Cockermouth* and *Whitehaven,* washed by the Solway Firth; the south-west coast of *Whitehaven, Bootle, Ulverston,* overlooking the Irish Sea; and lastly the southern coast of *Ulverston* and the south-western opening of the mouth of the Ken, in the *Kendal* district, which are influenced by Morecambe Bay and its tidal peculiarities.

In the above description all the Cumberland and Westmorland districts have been named, except Longtown; this will be included with the rest when discussing the Cumberland districts outside the inland boundary line.

The Hydrography of the Area.

A knowledge of the river systems of a country is the necessary key to a knowledge of its *aspects,* the most important factor in its local climates; this step necessarily leads to the study of land configuration, so that from hydrography we are naturally and almost imperceptibly led to include the physical geography and then the geology of the area under consideration.

Every river course that carries its waters to the sea by a single outfall may be considered an independent river; and the area from which it gathers its waters is known as its *catchment-basin*, which is separated from neighbouring catchment-basins by its *rim*, or *water-parting*, that is, the line of highest ground around the river's gathering-ground. The main water-parting of an island or a continent, such as Great Britain or Europe, is known as its *back-bone*. The back-bone of Great Britain extends from Duncansby Head on the extreme north-east of Scotland to the extreme south-west at the Land's End, Cornwall. This main *water-parting* separates the river systems on the east side of England from those of the west, the former emptying themselves into the North Sea, which now fills up what has been termed above the Great Thames Valley during the continental period when these eastern rivers were so many tributaries to the great river of that age; the latter discharging their waters into the Atlantic Ocean, Irish Sea, and St. George's Channel, as tributaries to the river of the Great Seine Valley, now covered by the English Channel. A most important part of this main *water-parting* or *back-bone* forms, as has been explained in the last chapter, the natural inland boundary line of our *area*, and will presently claim attention as an important factor in the climate of this region.

From the moment that my investigations, in 1868, led me to the discovery that those subject to pulmonary tubercle were intolerant of forcible air-currents, especially when intensified as draughts by the funnel-like configuration of the mouths of some river-valleys, I have never despised studying the smallest catchment basin; for the smallest, equally with the largest, tells us much of the aspects, and their direction found within the boundaries of their water-partings, and whether they are exposed to the full force of the winds which the consumption map has proved to be so fatal to those suffering from tubercle in the lungs.

The Rivers falling into the Sea at the Coastal Boundary from the North to the South :—

(1) *The Solway Firth*, which receives the waters of the rivers *Sark*, *Esk*, and *Eden*, must be considered as the mouth of the last river, to which the others are tributary. The succeeding rivers, however, are independent, these are (2) the rivers *Wampool*, and (3) *Waver*, which at low tide are seen to unite in the broad sands of Morecambe to the south of the mouth of the Eden; (4) the *Ellen*, falling into the sea at Maryport; (5) the *Derwent*, which is the effluent of many lakes, Thirlemere, Derwent Water, Bassenthwaite Water, Buttermere, Crummock and Lowes Waters, and carries their waters to the sea, into which it falls at Workington, after passing the town of Cockermouth; (6) the *Ehen*, the effluent of Ennerdale Water, which, after running along the coast in a southerly direction, joins (7) the *Calder* and the *New Mill Beck* on the foreshore, a little to the south of Sellafield station on the Whitehaven and Furness Junction Railway. The coast line is then broken by another triune river mouth, (8) the *Esk*, which receives near the foreshore, (9) the *Irt* that drains Wast Water, and (10) the effluent of Burnmoor Tarn, the *Mite;* the next in succession are (11) *Annaside Beck*, on which Bootle stands, (12) the *Duddon*, (13) *Coniston Water*, (14) the *Leven*, which drains Windermere Lake, and lastly (15) the *Kent*, on which Kendal is built. Such is the bare list of the rivers found in the area; it will now be fitting to see what relations they bear to the different climate and disease factors in each of the districts. Of these the most important are the great water-partings that form the natural inland and transverse boundaries of the greater portion of the area.

Inland Waters, the Lakes.—Omitting the Tarns and some other very elevated collections of water on the flanks of the mountains, there are sixteen Lakes, which must be studied in the district in connection with its local climates and diseases.

Height above the Sea.—Of these sixteen masses of water there are three having their surfaces over 500 ft. above sea level; two between 400 and 500 ft.; three between 300 and 400 ft., five being 200 ft. and 300 ft., and three between 100 ft. and 200 ft.; the average height being 326 ft.; the highest being Hawes Water, 694 ft., and the lowest Windermere, 134 ft.[1]

Lake Areas.—If we take these sixteen lakes, including Windermere, Esthwaite, Coniston, Wast Water, Ennerdale, Crummock Water, Buttermere, Lowes Water, Thirlemere, Derwent Water, Bassenthwaite, Ullswater, Brothers Water, Hawes Water, Rydal Water, and Grasmere, and ascertain the superficial area of each, we shall find that the aggregate amount of water expanse equals 21 square miles and 117 statute acres. A very important water surface, even when split up into detached masses. These areas of lake-water are shared by 28 out of the 235 parishes or townships which constitute the Lake District.

Lake Parishes.—These 28 lake-parishes (parts of which are washed by the lake waters, and on whose shores a considerable section of the population live) are important therefore, and the following facts relating to them should be known.

In the first place, eight per cent. (8·08) of the lake population occupy these 28 parishes, out of which in 1871 there were 9,194 females, or 8·75 per cent. of the whole female population. The numbers being as follows:—

Population of the seven lake districts, 1871: males 105,730, females 105,014, total 210,744; population of the 28 lake parishes: males 7,841, females 9,194, total 17,035. The females are distributed among the seven lake districts as follows—in the 2 lake-parishes of Penrith, 735 females; in the 11 of Cockermouth, 3,529; in the 2 of Whitehaven, 399; in the 1 of Bootle, 167; in the 5 of West Ward, 1,478; in the 4 of Kendal, 1,702; and in the 3 of Ulverston, 1,184; total 9,194.

[1] See description of "The Contour Map" (chap. vi.).

This section of the population may be said to live under the immediate influence of the twenty-one square miles of water surface; a climatic factor that must have great influence on the health of those evidently within its power—and whether such a body of water be full of life or full of death is a subject of grave importance. Whilst this lake-water area is fresh on our minds, let me draw attention to the vast difference that obtains between free and imprisoned waters, as the former are well and perfectly represented in the English Lake Districts; where waterfalls, cascades, torrential rivulets abound, and, as they dash over the precipitous rocks and along their boulder-laden courses, are thrown into spray-form high into the pure mountain air, which they entangle in their snow-white meshes, and rush off with to the lakes below, to promote health and vigour in every being they contain, belonging either to vegetable or animal life—such is the function of these free, unfettered waters; and we all know how that function is performed, and, whilst contemplating the mode in which it is so beneficently and so vigorously fulfilled, cannot help recalling to our minds those simple rhyming lines of the poet Southey, who, with feeling worthy of an observant man, in language simple enough for his child, described how these free waters went about their work at the foot of Lodore. "Here it comes sparkling, and there it lies darkling; now smoking and frothing.—The cataract strong, then plunges along, shaking and raging, as if a a war waging—showering and springing, flying and flinging —and glittering and flittering, and gathering and feathering, and whitening and brightening."

Let us now transport ourselves from the scene where free waters in the exuberance of their liberty are carrying out the beneficent dictates of nature, where they are the ministers of health and vigour, to some low-lying lands afar off, where the configuration of the country has been so moulded as to render it impossible for these high functions of water to be fulfilled

—where, in fact, the alluvial and other clayey flats of the low-lying land through which sluggish rivers wend their way from their sources to the sea, are so fashioned as to convert them into traps or prisons, ready to seize upon the errant waters of a flood, should they be obstructed in their course by over-crowding between the river's banks, and thus made to extravasate beyond them.

How different is the present scene, how different the future effects! The imprisoned waters, even at first, are seen to have brought with them, not health and vigour, but death and destruction in all their varied forms, the foul washings from cultivated land, manured with every kind of filth, the excrement of man and the lower animals that surround him, dead and dying vegetable matter; the sewage from towns and villages, and the out-casts of factories; and lastly the newly dead trees and herbs that have been overwhelmed by the extravasated flood. What the future? For days, perhaps weeks, the stagnant and imprisoned waters lie upon the surface of what were a short time since luxuriant meadows, bright in their green garment of grass, calm and still it is true, but not inert; their function is not to bring health and vigour to the herb that lies beneath them, but death and corruption. The once live-grass and its associated herbs when drowned, die and decay; their decay is accompanied by the extrication of foul gases which pollute the air, and acids that sour the soil, creating obnoxious local climates that betray their existence on the map of the medical geographer, and give evidence of their deadly work wherever his dark blue signs, denoting excessive mortality from certain causes, are imprinted.

This sketch is far from being overdrawn, for we are as yet only on the threshold of an investigation that will prove rich in results if only followed up with well-directed patience and labour.

There is a wide range between the live-waters of the moun-

tain cascade, the flood-preventing lake, and the dead-waters of the flood of the plain; but its entire width must be travelled over if we would learn how to profit by its teachings.

CHAPTER V.

SECTION I.

The Registration Districts of Cumberland, Westmorland, and the Lake District—Their Number, Names, and Boundaries—Hydrography—Rivers and Lakes—Table of Rivers' Length—Area of Catchment Basins—Sources—The Relation of Rivers to the Registration Districts—*Longtown*, Sark, Esk, Liddel, Lines—*Wigton*, Wampool, Waver—*Cockermouth*, Ellen, Derwent—*Whitehaven*, Ehen, Calder—*Bootle*, Irt, Mite, Esk, Buckbarrow-Beck—Duddon—*Ulverston*, Coniston Water and Leven—*Kendal*, Kent, Lune—*East Ward*, Eden and Lune—*West Ward*, Lowther and Eamont—*Penrith*, Eden, Petterill—*Brampton*, Irthing—*Carlisle*, Eden, Petterill, Calder—*Alston*, The South Tyne—Rivers and Inland Ventilation—Tidal Wave—Catchment Basins—Gravitation of Water and the Slope of the Land—Aspect—Hippocrates—How a River-valley should be studied—Its Trend or Axis—The Aspects of its Sides—The Eden—The Direction of its Axis—The Aspects of the Sides of its Valley—Prevailing Winds—Their Relations to the Eden Valley—Summary of the Courses of the Rivers in each District.

SECTION II.

The Lakes in the Cumbrian Area.

Divided into four Areas.—I. *The North-Western*—Ennerdale Water—Buttermere—Crummock Water—Lowes Water—Derwent Water—Bassenthwaite Water—Thirlmere—Their Affluents and Tarns—II. *The North-Eastern*—Ulles Water—Hawes Water—Their Affluents and Tarns—III. *The South-Eastern* — Kentmere — Windermere — The Affluents, Lakes, and Tarns of the latter, *viz:* of Grasmere, Rydal Water, Elter Water, Esthwaite Water, etc.—IV. *The South-Western*—Coniston Water—Burnmoor Tarn—Eskdale—Wast Water.

THE *Registration Districts of the Area—Number. Cumberland* (40) [1] contains nine registration districts: *Alston*

[1] The figures within parentheses (40) represent the registration numbers of the counties and districts for the period 1851–70; since then some slight alterations have been made.

(564), *Penrith* (565), *Brampton* (566), *Longtown* (567), *Carlisle* (568), *Wigton* (569), *Cockermouth* (570), *Whitehaven* (571), and *Bootle* (572), which are divided into twenty-eight sub-districts, at present not available for the medical geography of the diseases under discussion, although they are for births, deaths from all causes, and diseases termed *zymotic* to a certain extent. Dr. William Farr expressed to me a hope that, at some future day, these sub-districts would take the place of the districts in the supplements, and thus enable the medical geographer to localize the occurrence of disease among males and females separately more directly than is possible by means of the larger unit.

Westmorland (41) contains three registration districts: *East Ward* (573), *West Ward* (574), and *Kendal* (575), which are further divided into ten sub-districts: *Lancashire* (34), although it is divided into twenty-six registration districts, only one *Ulverston* (486) is included in the area under discussion, in consequence of its forming a part of the Lake District. Why Ulverston is not included in the county of Cumberland is as difficult to answer as, why Alston is. Ulverston is divided into six sub-districts; *Barrow-in-Furness* is now made a separate district. Within, therefore, the *Cumbrian Area* (by which term that part of North-Western England including the counties of Cumberland, Westmorland, and the English Lake District, will hereafter be described), there are thirteen Registration Districts, and forty-four sub-districts; the former will, however, only be used in this work for the reasons already given.

Boundaries.

It will be unnecessary to give a written description of the boundaries of the thirteen registration districts, as the reader has an opportunity of studying their relations to each other by means of the several maps, in which they are all distinctly defined.

Hydrography.—Rivers and Lakes.

If the reader will consult "The Plan of the Catchment Basins of the Rivers of England and Wales," that accompanies the Report on the Salmon Fisheries in England and Wales, published at the Ordnance Survey Office under the direction of Captain A. de C. Scott, R.E., Colonel Sir Henry James, R.E., F.R.S., etc., February, 1861, on a scale of ten statute miles to the inch, he will find that our Cumbrian area is divided into eighteen catchment basins, the rivers of which fall into the Irish Channel, and that it shares the upper parts of three others that have an opposite course into the North Sea. The names, length, area, and sources of each of the former rivers are appended in the following table :—

Names of Rivers and Tributaries.	Length in Miles.	Area of Catchment Basins in sq. m.	Sources and Remarks.
15. Esk	$8\frac{1}{2}$ ...	143 ...	From Scotch Dyke to the sea.
Line and White Line ...	$24\frac{1}{2}$		
Liddel	$10\frac{3}{4}$		
16. Sark	7 ...	3 ...	From Scotch Dyke to the sea.
17. Wampool ...	18 ...	62 ...	Source near Pastures to the sea near Anguton.
Wize	8		
18. Waver ...	$15\frac{3}{4}$ ...	48 ...	Source near Brocklebank Fell to the sea.
19. Ellen	$20\frac{3}{4}$ ...	54 ...	Source near Caldbeck Fells to the sea.
20. Derwent ...	$35\frac{1}{2}$ ...	268 ...	From Borrowdale Fells to the sea.
Greta ...	$13\frac{1}{4}$		
21. Ehen ...	$14\frac{1}{2}$ ...	59 ...	From Ennerdale Water to the sea.

Names of Rivers and Tributaries.	Length in Miles.	Area of Catchment Basins in sq. m.	Sources and Remarks.
22. CALDER	$8\frac{3}{4}$	23	Source at Blakeley to the sea.
23. IRT	$16\frac{1}{4}$	48	From Haycock to Mite River at Ravenglass.
24. MITE	$8\frac{3}{4}$	10	From Screes to the sea at Ravenglass.
25. ESK	$17\frac{1}{2}$	43	From Esk Horse to the sea at Ravenglass.
26. BUCKBARROW BECK	6	16	Source at Great Paddy Crag to the sea.
27. DUDDON	$27\frac{1}{4}$	117	Source at Three-shire Stone to the sea.
28. CONISTON WATER	$10\frac{1}{2}$	36	From head of Lake to the sea.
29. LEVEN	$6\frac{1}{2}$	123	From Windermere Lake to the sea.
30. KENT	$28\frac{1}{2}$	196	From Kidsley Pike to Holm Island.
Betha	$16\frac{1}{2}$		
Mint	$11\frac{1}{2}$		
Winster	$11\frac{1}{4}$		
Sprint	10		
31. EDEN	$70\frac{1}{2}$	916	From Eden Head to the Solway Firth.
Irthing	36		
Calder	$25\frac{1}{2}$		
Petterill	$25\frac{1}{2}$		
Eamont	$10\frac{1}{2}$		

The South Tyne drains the district of Alston, where it has its source; it then joins the North Tyne, forming The Tyne, which falls into "The Narrows" at N. Shields.

The Lune, after arising at Lune Head, passes through the south-east corner of Kendal district and thence into Morecambe Bay.

The Relation of the Rivers to the Registration Districts.

Taking the rivers in the order observed in the table above, it will be found that each of the districts is drained by one or more of the rivers contained in the list.

15. The Esk enters *Longtown* at its N.W. boundary, where it joins the *Liddel* (not shown in the District Map), which forms the boundary between Cumberland and Scotland; and at the S.W. boundary of the district is joined by the rivers *Line* and *White Line*, which take a S.W. course to the Solway Firth from the extreme N.E. boundary.

16. The Sark is a small border river rising in Scotland, and separates *Longtown* from that part of Great Britain.

17. The Wampool rises in *Wigton*, and takes a N.W. course to the Solway Firth.

18. The Waver also rises within *Wigton*, and falls into the same estuary as the *Wampool*, taking an almost parallel course to that river.

19. The Ellen rises above the lakelet *Over Water* in *Wigton*, takes a course at first in a N.W. direction, after which it crosses the northern boundary of *Cockermouth* in a S.W. direction, and falls into the sea at Maryport.

20. The Derwent is, however, the river of *Cockermouth*, over which it ramifies in all directions. One of its four principal tributaries, the *Greta*, rises in Penrith district and joins the main stream near Keswick, where it receives the effluent of Derwent Water, after the effluent of *Midmere* has added to its waters at the boundary line between Cockermouth and Penrith. From Keswick it proceeds to Bassenthwaite

Water, in a N.W. direction, and as the effluent of this lake it moves round in a S.W. direction, receiving near the town of Cockermouth the effluent of the *Buttermere* and *Crummock* Waters, after which it pursues a S.W. course to Workington, where it falls into the sea.

21. The Ehen, not named in the map, but easily traced as effluent of *Ennerdale Water*, is the river of the *Whitehaven District;* its source, called the *Liza*, takes its rise on the northern side of the great transverse ridge, and, after supplying the lake, its waters emerge as its effluent *Ehen*, which moves round from its original N.W. course to the south around the west end of the great transverse ridge, and enters the sea near Sellafield station.

22. The Calder is another river of the Whitehaven district, which, after rising from the south side of the transverse ridge, near the Iron Crag and Caw Fell, proceeds in a S.W. direction to the sea, which it enters a short distance to the south of Sellafield station. It is not marked on the map.

23. The Irt is the effluent of the *Wast Water*, which is supplied by its sources from Haycock and other heights. As effluent, it takes a circuitous course in a S.W. direction, eventually falling into the triple estuary at Ravenglass, which receives the rivers *Mite* and *Esk*. It belongs to *Bootle* as well as the two following.

24. The Mite traverses Bootle in a S.W. direction after rising from the Screes, ultimately falling into the triple estuary at Ravenglass, between the *Esk* and the *Irt*.

25. The Esk, which, like the Mite, is omitted in the District Map, rises on the flanks of Scafell Pike and courses through Esk Dale in a S.W. direction, which it continues until it reaches the most southerly of the river mouths forming the triune estuary at Ravenglass. All these three rivers drain *Bootle District*, which, however, enjoys part of another river, the *Duddon*.

26. Buckbarrow-Beck, a small stream having its source

at Great Paddy Crag, follows a similar S.W. course through Bootle to the sea.

27. The Duddon, which has its source at the Three-shire Stone to the north of Bootle, takes its course in an almost S. direction to its large estuary, during which it forms the boundary between *Bootle* and the adjoining district of *Ulverston* (Lancashire). Its tributaries have their sources, on its right bank from *Bootle*, and on its left from *Ulverston.*

28. Coniston Water belongs entirely to *Ulverston;* is almost due S. in its direction, drains the lake of the same name, and finally empties its waters into the sea at the estuary of the river *Leven.*

29. The Leven, the effluent of the Windermere, or Winandermere Lake is essentially an *Ulverston* river. Although its sources, which act as effluents to Grasmere, Rydal, and Elter Waters, take their rise in the north-western portion of the *Kendal District.* In *Ulverston* the general direction of its course is S. and S.W.; in *Kendal,* however, the sources have a S.E. trend. It falls into Morecambe Bay.

30. The Kent, or Ken, is devoted to the *Kendal District.* Its main valley, extending from Kidsley Pike to Holm Island, in Morecambe Bay. In its upper part, between Kentmere and Kendal, it runs rather in a S.E. direction; but after passing that town it curves round to the S.W., and falls into Morecambe Bay through a wide estuary.

31. The Eden is the most important river of the Cumbrian area, for its main stream and tributaries drain five out of the thirteen districts, namely, *East Ward, West Ward, Penrith, Brampton*, and *Carlisle.*

It rises in the S.E. corner of *East Ward*, at Edenhead, on the N.W. side of the water-parting from which the river Ure springs on the S.E. Its valley from this point has a N.W. course, which it continues as the boundary-line between *West* and *East Ward.* It then continues in the same direction as the boundary between *West Ward* and *Penrith*, and at the

point, where it ceases to be so, it receives its effluent tributary, the river *Eamont*, after it has carried off the waters from *Ulles Water* and *Hawes Water*. The main direction of its tributary, however, is at right angles to the *Eden*. After the junction of the *Eamont*, the *Eden* crosses *Penrith* still in a N.W. direction, until it reaches the northern boundary of this district. It may be remarked that one of its tributaries, the *Petterill*, after rising within the same district, takes a similar and almost parallel course to the boundary between *Penrith* and *Carlisle*, in the latter of which it joins the main stream a short distance to the east of the city of Carlisle. After leaving *Penrith* the *Eden* pursues still its N.W. direction, whilst acting as the boundary between *Brampton* and *Carlisle;* but in ceasing to do so it curves round to the N., until the river *Irthing* joins it, after draining *Brampton*, which it runs through in a S.W. direction from its source in Northumberland to the *Eden*.

After receiving the river *Irthing*, the *Eden* makes a sharp turn to the W., and then pursues a circuitous route through the N.E. half of *Carlisle* in a N.W. direction, and after receiving the *Petterill* and *Caldew*, near the city, falls into the upper part of the *Solway Firth*.

The CALDEW rises near the boundary-line dividing *Penrith* and *Wigton*, and takes a N. course through Carlisle to the *Eden*.

The SOUTH TYNE, which drains *Alston*, takes a N. by W. course through it, after rising in this district. It does not properly belong to the Cumbrian area.

The LUNE, which rises at Lunehead, in East Ward, pursues a S. direction whilst crossing the S.E. corner of the Kendal district.

Having drawn the reader's attention to the facilities afforded by the river courses of Great Britain to the immigrating fauna of pre-historic times, and having shown how these same valleys enable the sea winds to penetrate into the in-

terior of the land, ventilating and purging it of stagnant and malarious residual air, he will be prepared to find that our rivers play an important part in Medical Geography, and that it is necessary to enter into detail with regard to the direction of their courses; for their efficacy as ventilators depends mainly on the direction of their trend. Our rivers not only give, in some instances, free access to the prevailing winds, but also to the tidal wave, with its accompanying freshening sea breeze, and uplifting of the lower strata of air twice daily at least.

The catchment basins of the rivers of the Cumbrian area, as seen on the map referred to, remind us of the facets cut by the lapidary on a stone; in fact, the resemblance increases as we think it out. In the first place, those catchment basins are the results of nature's graving tools,—rain, snow, ice, water,—by which she accomplishes sub-aërial denudation upon the crust of the earth, which, as we all know, presents a very varied form; in fact, it would be difficult to find two places exactly alike in either structure or form. However, free water always finds out the course of least resistance and follows it, indicating at once the slope or *aspect* of the surface on which it operates. The courses of the rivers therefore give us the clue to the aspects of a region, considered so necessary in advising people as to where they should or should not reside. Hippocrates dwelt particularly upon the value of a knowledge of aspects, and laid down rules for finding them.

A river valley must always be studied at least from three points of view. (1) The direction of its trend or axis; and when this is ascertained, then the question arises, Can the winds from the sea find their way up *through* it easily? or Do they blow *over* it in consequence of its being at right angles to their course? The rivers in the Cumbrian area present examples of all kinds of land ventilators from the worst to the best, and will presently be used to illustrate this subject.

(2) The *aspects* of the sides of the valley, which are neces-

sarily at right angles to the course of the river, and opposite each other, not only in position, but in character of climate.

(3) The structure of the bed of the river and that of the valley which it drains. This will be considered under "Geology" (chap. vii.).

As the river valleys will necessarily be dealt with in the subsequent part of this work, in which the physical geography and geology of the Cumbrian area are dealt with, it will be only necessary to summarize the facts which have been given in this chapter, as to the actual direction of the water-courses named, and their relation to the sea and land winds.

The Eden. If we draw a line from the source of this river, from the S.E. corner of East Ward to the point where it falls into the Solway Firth, and then find the centre of the line, which will be seen to be about the crook in the Eamont between the junction of the Hawes Water effluent and that of the Eamont itself with the Eden, and place the centre of a card having a mariner's compass upon it (a piece of tracing linen so marked is very convenient for this purpose), it will be ascertained that the mean course of this river is from S.E. by S. to N.W. by N., and that the aspects of the slopes of the *right* and *left* sides of the valley are respectively S.W. by W. and N.E. by E.; that is to say, the slopes on the N.E. by E. side of the line, or *right* bank of the river, will look towards the S.W. by W. part of the sky; and that the S.W. by W. side of the line, or *left* bank of the river, will look towards the N.E. by E. part of the sky. In other words, the *left* bank and its slopes will catch the rays of the *rising* summer sun, when they appear above the Pennine chain, and the *right* bank and its slopes the rays of the *setting* winter sun, whilst they remain above the sky-line of the central mountain-mass; a matter to be well considered both by the medical practitioner and the agriculturist.

What is here meant by the valley-side having a certain aspect, such as S.W. by W., or N.E. by E., is that, taking it

as a whole, the majority of its square miles or acres would enjoy such aspects; this will be better understood when we come to consider the same subject in the description of the "Contour Map."

If we look at any valley-side on a good map, such as the one-inch Ordnance, we cannot but notice the almost innumerable furrows that the minor water-courses have made down the flanks of the heights that form it; now each of these, even the smallest, will present on a small scale all the features of the most considerable river. But it will be noticed that, however diverse may be the direction of these tributary streams, they are all influenced by the main slope. Again, supposing some of the acres on a valley-side have an aspect contrary to the main one, as many will be found to have in any large area, we must not forget that each acre either enjoys the advantages of a good general aspect or suffers from the disadvantages of a bad one.

As a rule, the S.W. and N.E. winds are the prevailing winds in Great Britain (the approximate prevalence of each wind for England and Scotland will be given in Chapter IX.); such winds have the axes of their currents nearly at *right angles* to the axis or trend of the River Eden. These winds, therefore, would blow *over* its valley, and not *up through* it, nor down through it, ventilating and purging it of its residual air. The N.W. wind would, however, fulfil this function, and when a strong and pretty prevalent wind, would do so effectually. But it must be remembered that it does not come straight from the sea, as it has to sweep over a considerable portion of Scotland before it crosses the Solway Firth, and enters the mouth of the Eden. The same may be said of its antagonist the S.E.; but the latter, before entering the valley of the Eden, has to break its force against that portion of the Pennine chain forming the inland boundary, which separates the source of the Eden from that of the Ure. Still, if it descend into the valley

and sweep along it to the N.W., it would do much towards ventilating it. It is, however, not a sea-wind; for, before reaching the boundary of the Cumbrian area, it must travel over a wide expanse of England. We may therefore sum up as follows: (1) The sides of the valley of the Eden enjoy aspects on which the rays of the summer sun fall at its rising and those of the winter sun at its setting, and that therefore each side in its turn would receive a certain amount of the sun's morning, noon, and afternoon rays during the summer. (2) That the Eden valley is shut out from the direct influence of the sea winds, but that it affords free access to the N.W. and at times S.E. winds, which partially ventilate it during their prevalence.

If we now briefly review the courses of the rivers of the other districts, we shall obtain a good general idea of the means by which the atmospheric currents obtain access to the interior of the Cumbrian area, and from what points of the compass they are derived, taking the districts in their registration order:—

Alston, an elevated district on the Eastern watershed of England, is fully exposed, and its main valley, that of the South Tyne, has a N.N.W. direction; and open therefore to a land wind.

Penrith has already been discussed (p. 77).

Brampton is drained by a tributary of the Eden—the Irthing—the valley of which takes a W.S.W. direction to the main river, and offers free access to winds from that quarter.

Longtown, the valley of the river *Line*, has a direction nearly S.W. from the N.E. corner of the district; the wind that ventilates it is a sea-wind, and approaches it straight from the Solway Firth.

Carlisle was included in the Eden Valley (p. 77).

Wigton. The rivers *Wampool* and *Waver* open on the Solway Firth, after a N.W. course, and give free access to winds from this quarter, which are, however, more land than sea

currents, as they pass over a considerable portion of Scotland.

Cockermouth. The *Ellen* offers every facility to the sea winds from the S.W., and so does the *Derwent* in the latter part of its course; but at the commencement of its career it has a N. course; whilst in its middle portion, its valley in which Bassenthwaite Water lies, the prevailing S.W. winds would blow over it. The southern and higher portions of the *Derwent,* which act as affluents and effluents to *Derwent Water* have their courses from S. to N., and are shut out from the good influence of the sea winds altogether.

Whitehaven. It will be seen that the effluent of Ennerdale Water, the river Ehen, in the last part of its course, has a S. direction, and open to the full force of the sea winds, but that the valley, in which the lake and its affluent (*Liza*) lie, are sheltered from these winds by the western portion of the great transverse ridge.

Bootle has all its river valleys more or less lying towards the S.W., and giving the freest access to the sea winds from that quarter.

Ulverston. The river and lake valleys in this district have a more or less S. direction; and the funnel-shaped estuary into which they empty their waters promotes the free ingress of the sea winds.

Kendal. The river *Kent,* which is the principal river of this district, has first a S.E., then a S., and lastly a S.W. course, which enables it to offer every facility to the S.W. sea winds that approach it from Morecambe Bay.

Such are the main facts connected with the river-system of the Cumbrian area, and when once mastered the reader will have little difficulty in following the author in his description of the disease-distribution. I shall conclude this chapter with a short account of *The Lakes* in their relation to the Registration Districts, some of the more important of which have already been given in dealing with the river-system.

Section II.

The Lakes of the Cumbrian Area.

The Lake District is defined on the maps by a broad shaded line around the inland boundaries of Cockermouth, Penrith, West Ward, and Kendal; and between the points where this line abuts upon the Solway Firth and Morecambe Bay, the sea forms its boundary.

The Lakes, and the rivers which feed them, owe their existence to the Great Transverse Ridge, which has already been referred to, and which will again be noticed in the chapter on Physical Geography, and in the description of the "Contour Map."

Let the reader take the 3° W. Long. line where it crosses the River Caldew to the left bank of the estuary of the River Leven, and then at nearly right angles draw a line along the course described at p. 59, and he will find the Lake District divided into four nearly equal parts: two to the north of the Transverse Ridge, and two to the south, which may be described as (1) The North-Western; (2) the North-Eastern; (3) the South-Eastern; and (4) the South-Western. We will begin with the Lakes to the north of the Great Transverse Ridge, and give the names of one or more of the sources of their affluents, and those of the heights forming the water-parting nearest their sources: the height above sea-level, the area, and depth of each lake will be given, when ascertainable, from the Ordnance Survey maps on a scale of one inch to a statute mile, or from other reliable sources.

The Northern Lakes. (1) *The North-Western Area.*

Ennerdale Water. This lake lies in the Whitehaven District, at a height of 369 ft. above the sea; has an extreme length of 2½ miles, breadth ¾ mile, and a maximum depth of 80 feet.

The river *Liza* is its principal affluent, which rises near the summits of the north-western flank of Brandreth (2,344 ft.), *Green Gable* (2,500 ft.[1]), and Kirk Fell (2,631 ft.), and lies in a deep valley, the lofty sides of which separate it from *Buttermere* and *Crummock Water* on the north, and *Wast Water* on the south. It has a W.N.W. direction. Its effluent, the river *Ehen*, has been described (p. 75). The course of the valley of the effluent, *Ehen*, can only affect the death-rates in the Whitehaven District, as above Ennerdale Mill there are few people living. *Cleator* and *Egremont* are the largest towns on this river, after it has received the river Keekle.

Buttermere and *Crummock Water*, now two masses of water, formed at one time a single lake[2] five or six miles in length.

Buttermere has an extreme length of 1¼ miles, and of breadth ½ mile, whilst Crummock Water is 3 miles long and ¾ mile broad. They vary too in depth. Buttermere has a depth of 93 feet, whilst the lower lake, Crummock, has one of 132; Buttermere is 331 feet, and Crummock Water 321 feet above the level of the sea. The affluents of these two lakes are to be found in that wild but lovely region characterized by Fleetwith Pike (2,126 ft.), Honiston Crag, Grey Knotts (2,287 feet).

Lowes Water. As this lake empties itself into the Crummock Water, it will be well to include it in this group, although its source of water has nothing in common with the other members. It has a small unnamed affluent; a length of 1 mile, and breadth of ½ mile; a depth of 60 feet, and a height of 429 feet above sea level. The effluent of these three lakes is a tributary of the Derwent, the *Cocker*, the

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[1] The figures represent the height of the part of the Transverse Ridge named.

[2] Mr. Ward says that of lakes filled up in whole or in part, mention may be made of Buttermere, which originally extended into Warnscull Bottom on the south, and was continuous with Crummock on the north.

course of which is north-westerly. The whole of the valley from White Hall, Buttermere, to Cockermouth, is well populated; its direction is W.N.W. After its junction with the Derwent, the latter bends in a S.W. direction, passing through a somewhat thickly-populated valley, and entering the sea to the north of Workington, which would be influenced by its sea inlet. The Buttermere, Crummock Water and Lowes Water may be termed the Cocker group of the Derwent Lakes; we now come to the Middle or Derwent Group, consisting of *Derwent Water* and *Bassenthwaite.*

Derwent Water has a length of 3 miles, a breadth of 1¼ miles, and a depth of 72 feet; it lies at a height of 238 feet above sea level. Its affluent is the *Derwent River* itself, which is singularly associated in its course with tarns and lakes. The several sources of this river are to be seen flowing from the Borrowdale Fells into Borrowdale: thus the main source may be traced from Allen Crags (2,572 ft.), through the valley at the foot of Seathwaite Fell (1,970 ft.), and Glaramara (2,560 ft.), where it is joined by the most westerly stream that has its source in Sprinkling Tarn, 1,960 feet above sea level, and then feeds *Styhead Tarn* (1,413 feet). Both these sources rise from the northern flanks of Great End (2,984 feet) near the summit, this mountain taking part in the great Transverse Water-parting or Ridge. Another stream, *Longstrath Beck,* has its source in Angle Tarn, to the north-west of Rossett Crag (2,106 ft.), and Bow Fell (2,960 ft.), another member of the Great Transverse Ridge. A third affluent of Derwent Water is the Watendlath Beck, which has its source in Coldbarrow Fell, just above *Blea Tarn* (1,562 ft.), the rivulet then passes through a *lakelet* at Watendlath (847 ft.); so that the affluents of Derwent Water are actually in connection with five tarns before they reach Derwent Water.

Borrowdale, in which three affluents lie, has a direction from S. to N., and therefore receives the winds from the latter

point after they have passed over and had their force broken by Skiddaw (3,054 ft.). The valley is moderately populated, but the great centre is Keswick, the population of which would naturally dominate that of the valley generally.

Bassenthwaite, which is connected with the lake, just discussed, by the River Derwent, lies at a slightly lower level than Derwent Water, being 226 feet above sea level; it has a more north-westerly direction than the last, and is considerably longer, being $4\frac{3}{4}$ miles long and $\frac{3}{4}$ mile broad; its extreme depth is 75 feet.

The Derwent acts as its effluent at its N.W. extremity, and then takes a somewhat sudden turn to the W., under the lee of the heights which extend to the west from Skiddaw.

Thirlmere belongs to the *Greta* branch of the *Derwent*. Like Derwent Water, it lies in a deep valley trending from S. to N., exposed to the northerly winds, but protected from them by the heights of Blencathra (2,847 ft.), or Saddle-Back. This lake, which has been selected for the water supply of Manchester, is 533 feet above the sea level, has a length of $2\frac{3}{4}$ miles, and a breadth of $\frac{1}{3}$ mile, and an extreme depth of 108 feet; *St. John's* Beck acts as its effluent and empties its water into the river *Greta*, which it enters at right angles near Threlkeld station. The valley is moderately populated.

The affluent of Thirlmere is Wyth-Burn, which rises on the north side of the transverse water-parting below the summit of *Sergeant Man* (2,414 ft.), after which it takes a north-easterly direction in the valley to the N.W. of that classic col, crossed by the main road to Keswick from Ambleside, near which the tumulus of Dunmail Raise marks the spot where the last of Cumbria's kings fought for independence against the English, which he only surrendered with his life.

II. *The North-Eastern Area.*

Ullswater is the principal lake in this area, which is separated from the North-Western by the lofty ridge having

a south and north strike, and the third highest mountain in the country in its midst, Helvellyn (3,118 ft.), which has Clough Head to the north (2,380 ft.), and Seat Sandal (2,415 ft.) to the south. From the eastern flank of this stupendous ridge the affluents of this beautiful lake lie, in the following order from the north, the *tarns* whence proceed the feeders of Ullswater:—

Keppelcove Tarn (1,825 ft.), and *Red Tarn* (2,356 ft.), just below the summit of Helvellyn; these empty their waters into the beck that flows down Glenridding; then Grisedale Tarn (1,768 ft.), on the N.E. of *Seat Sandal*, then *Brothers Water* (520 ft.), and lastly *Hayes Water* (1,383 ft.), both of which last derive their waters from Caudale Moor; five in all, the effluent streams of which at last unite at the southern end of *Ullswater* and form its principal affluent, the Goldrill Beck.

Ullswater is 477 feet above sea level, and at its deepest part 210 feet; its extreme length is $7\frac{1}{2}$ by $\frac{3}{4}$ miles. The river Eamont acts as its effluent, and empties its waters into the Eden. The whole valley, notwithstanding its somewhat tortuous course, has a mean N.E. direction. It is thinly populated. Its local climate is shared by the S.W. portion of Penrith District, and that of the N.W. of West Ward.

Hawes Water belongs entirely to West Ward. Its affluents are derived from the southern flank of Kidsty Pike (2,560 ft.), and two tarns, *Blea Water* (1,584 ft.), and *Small Water* (1,484 ft.), springing from the north of the Great Transverse Ridge, which separates them from the south-eastern area, and *Kentmere*. These waters unite into one stream, and fall into Hawes Water at its southern extremity. Hawes Water is 3 miles in length and $\frac{1}{2}$ mile in breadth. Its surface is 694 feet above sea level; and its greatest depth is 180 feet. Its effluent, Hawes Water Beck, carries off its contents, and shortly after joins the River Lowther at Bampton, which conveys them at last to the River Eamont. The

valley in which this lake lies has a direction from S.W. to N.E., and is very thinly populated.

III. *The South-Eastern Area.*

Kentmere. This little lake or reservoir lies in the vale between Lingmell End (2,183 ft.), and Ill Bell (2,476 ft.). Its affluent rises to the south of the Transverse Ridge, in the neighbourhood of the Roman Road. It is 973 feet above the level of the sea. Its valley is but sparsely populated. Its effluent, the River Ken, or Kent, runs through an important and well-populated area, and its local climate has much influence on the health of those who inhabit it.

Windermere lies entirely in this area, and is shared by the Kendal and Ulverston Districts. Its affluents, however, for the most part are derived from the South-Western Area, as will be seen by the map; but they will be described with the lake that they feed.

As the affluents of this lake are rather complicated in their relation to the tarns and lakelets above Windermere, it will be well to describe them each separately.

Troutbeck is a considerable stream having its source on the southern flank of Caudale Moor, part of the Great Transverse Ridge. It enters the lake on its eastern side, near Calgarth Hall.

Stock Gill has its source near the Screes and Kirkstone Pass. It is noted also for its *force*, or *waterfall*, near Ambleside, which town it passes through on its way to join the Rothay river; which, after receiving the waters of *Codale* and *Easdale Tarns*, acts as affluent and effluent to *Grasmere Lake* and *Rydal Water*. The *Rothay* derives one of its sources close to *Dunmail Raise*, on the south side of the great water-parting.

Codale Tarn has a level above the sea of 1,528 feet, on the flank of Thunacur Knott (2,351 ft.), *Easdale Tarn* (915 ft.), and *Grasmere* (208 ft.); the last of which is a mile in

length, $\frac{1}{2}$ mile in width, and 180 feet deep. *Rydal Water* is $\frac{3}{4}$ mile long and $\frac{1}{2}$ mile wide.

Elter Water derives its supply from *Stickle Tarn.* Lying 1,540 feet above sea level, on the flanks of the Langdale Pikes, its effluent, known as the Great Langdale Beck, then flows in a S.E. direction and falls into *Elter Water*, which is 187 feet above sea level; and on issuing from this lakelet assumes the name of Brathay, and at the site of the Roman DICTIS is joined by the river *Rothay*, which eventually, with its combined waters, falls into the Windermere, south of the ancient station near Brathay Hall. *Loughrigg Tarn* empties its waters into the Brathay just below *Elter Water.*

The *River Brathay* is the southern affluent of *Elter Water.* This river rises near the Three Shire Stone at the head of Little Langdale; it then proceeds in an easterly direction, and supplies *Little Langdale Tarn*, 340 feet above sea level, after which it pursues a circuitous course to *Elter Water*, at the last changing its direction almost due north.

Esthwaite Water lies to the west of Windermere. It is 217 feet above sea level, $1\frac{1}{2}$ miles long, by $\frac{1}{3}$ mile wide, and has a maximum depth of 80 feet. Its effluent, the Cunsey Beck, discharges its waters into Windermere between High Cunsey and Rawlinson Nab.

The effluent of Windermere Lake is the *River Leven*, the course of which, combined with that of the lake, both affording free access to the prevailing sea winds, must conduce greatly to the thorough ventilation of the valley in which they lie.

Windermere is 10 miles long, 1 mile in breadth, has a maximum depth of 237 feet, and is 134 feet above sea level, so that its bottom is 103 feet below that datum.

IV. *The South-Western Area.*

Coniston Water lies nearly in the centre of Ulverston District, is 147 feet above sea level, has an extreme depth of

160 feet, and has a length and breadth (at the widest part) of $5\frac{1}{4}$ and $\frac{1}{2}$ miles respectively.

Its affluents are characterized by *tarns* at their sources. *Low Tarn* (600 ft.) near Tarn Hows drains into *Yewdale Beck*, from which it derives its principal supply of water. This stream is derived from Tilberthwaite and Oxen Fell. It does not fall directly into the head of the lake, but on the western side a little above *Church Beck*, which has its source at High Fell, and then passes through *Levers Water*, 1,350 feet above sea level. It then takes a S.E. route through Coniston village, and empties itself into the lake just below the *Yewdale Beck*. *Goat's Water Tarn* (1,350 ft.) to the S.W. of *Coniston Old Man* (2,633 ft.), empties its waters into the beck that falls into Coniston Water at Oxen House Bay, in the southern third of the lake. The effluent of Coniston water is the river *Crake*, which falls into Morecambe Bay through the estuary of the *River Leven*.

Seathwaite Tarn, 1,210 feet above sea level, derives its waters from Seathwaite Fell, and discharges them by *Tarn Beck* into the river Duddon through its left bank.

Burnmoor Tarn (832 feet above sea level) lies on Eskdale Fell at the head of Eskdale, and empties its waters into the river Esk.

Wast Water, the last of the series, derives its supply from the flanks of the Pillar, Kirk Fell, Wasdale Fell, and Lingmell, after which last height the combined waters are named, and, as *Lingmell Beck*, fall in at the head of the lake; another affluent, *Nether Beck*, issues from *Scoat Tarn* to the west of Red Pike, takes a southerly course and falls into Wast Water on its N.W. side. On its S.E. side the lake is under the lee of the stupendous "*Screes.*" This lake is 3 miles in length, $\frac{1}{2}$ mile in breadth; has an extreme depth of 270 feet, whilst its surface is only 204 feet above the sea-level, so that its bottom at its greatest depth is 66 feet below it. The river *Irt* acts as its effluent, and falls into the sea as described (p. 75).

CHAPTER VI.

The Physical Geography of the Area.

Description of the Contour Map—Contour Lines—Isotherms—Isobars—A *Times* Weather Chart—Contour Maps—Black Combe, Mr. Penning—The Principal Mountain Masses of the Cumbrian Area—I. *The Scafell*—II. *The Helvellyn*—III. *The Skiddaw*—IV. *The Black Combe*—V. *The Bewcastle*—VI. *The Edenside*—*The Scafell*—The Radiating Ridges of the Scafell Mountain Mass—1. *The Western*—2. *The North-Western*—3. *The Northern*—4. *The North-Eastern*—5. *The South-Eastern*—6. *The Southern*—and 7. *The South-Western*—1. *The Western Ridge*—2. *The North-Western Ridge*—3. *The Northern Ridge*—4. *The North-Eastern Ridge*—Minor Heights to West of Windermere—Description of the View from Orrest Head—5. *The South-Eastern Ridge*—6. *The Southern Ridge*—7. *The South-Western Ridge*—*Recapitulation*—1. *Western Ridge*—2. *The North-Western Ridge*—3. *The Northern Ridge*—4. *The North-Eastern Ridge*—5. *The South-Eastern Ridge*—6. *The Southern Ridge*—7. *The South-Western Ridge.*

Description of the Contour Map.

ON looking at the "*Contour Map*" it will be seen to be so coloured as to represent in shades of *blue* and *brown* the altitudes of the several areas enclosed within certain *contour* lines; thus the areas coloured *blue* are *below* 500 feet, whilst those coloured *brown* are above that level. Again, each colour is represented by two shades: the *darkest blue* indicating the *lowest* levels, namely *below* 250 feet; and the *lighter blue*, altitudes between 250 and 500 feet; on the other hand, the areas coloured *brown* are divided into those coloured *light brown*, which shade characterizes such parts of the country as have a height between 500 and 1,000 feet above the sea level; whilst the *dark brown* distinguishes the mountain masses which rise above 1,000 feet.

Contour lines are lines of equal level used by surveyors to show at a glance the results of their field-work, so as to facilitate the operations of the engineer and geologist. By means of these simple lines sections of a field or of a whole country can at once be made, their gradients or slopes ascertained, and, what is of infinite service to the medical practitioner, their *aspects* determined.

With the knowledge how to read the expressions of a series of contour lines, the medical man is enabled, with a good contoured map before him, to decide at once when a locality is favourably or otherwise situated for his patient, without actually examining the place itself personally. It was this important consideration that induced me to construct contour maps for the two favourite health-resorts, Brighton and Scarborough, by which medical men, without ever having been in these towns themselves, are enabled to decide at once what aspects would be favourable and what obnoxious to the cases they might desire to send there. Before, however, pointing out how such maps are to be used by my professional brethren, it will be well to give a general description of the contour map before us, so as to familiarise them with the broad details of the area in this respect.

We are most of us familiar with the meteorological terms *isotherm* (ἴσος = equal and θέρμη = heat), and *isobar* (ἴσος = equal and βάρος = weight); the one applied to lines of equal *temperature*, and the other to those of equal *weight* or pressure (atmospheric).

Contours are Lines of Equal Level.

In the case of isotherms, these can be illustrated by a reference to the map under discussion; as the isothermal lines according to Dr. Alexander Buchan, M.A., F.R.S.E., for July, over this area have been inserted; those for January being given over the geological map.

Let us take the July *isotherms* :—At the two ends of the

most western crimson line will be found "60°," which means that the mean temperature, during July, is equal to sixty degrees, Fahrenheit, along the whole course of that line, after the corrections have been made for altitude in the actual local observations, that is, from 54° N. Lat., and Morecambe Bay to the Solway Firth, and 55° N. Lat., during which course the line crosses the great Transverse Ridge of Mountains. The isotherm 61° is seen just crossing the extreme south-eastern part of the Kendal District; these will be again referred to more fully in the chapter on Meteorology.

Now with regard to *isobars*, the weather charts, published daily in *The Times*, afford us ample illustration of the principle on which they are constructed and of their extreme value to science. The weather-chart (see p. 94) published in to-day's issue (26th August) of the above journal affords an excellent example o *isobaric* teaching. A depression had been advancing towards Ireland from the Atlantic since the 24th August, and *The Times* of the former date gives a weather-chart for Tuesday, 25th August, 6 p.m., in which we see the following isobaric arrangement, which to the accustomed eye tells its unmistakable tale as quickly to the meteorologist as a contoured map would to an engineer.

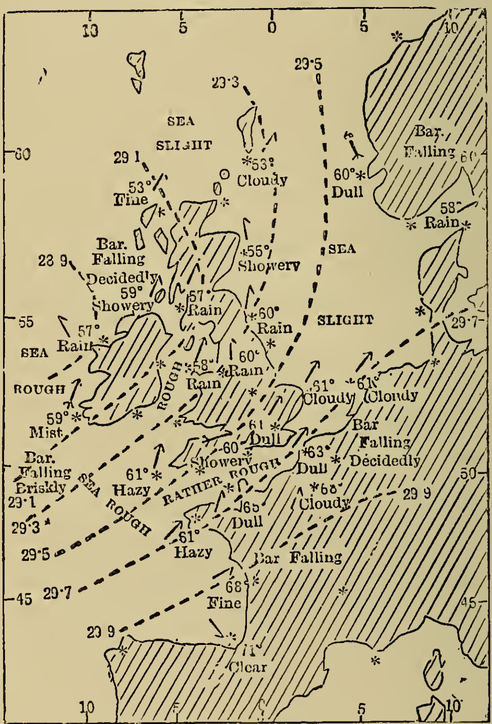
To the W. and N.W. of Ireland the "depression" spoken of is represented by a fragment of a circular *isobar*, which shows that, after corrections for temperature and altitude have been made, the barometer stood within this circular area at 28·9 inches (remarkably low for this time of the year). Going eastward we find that the next isobaric curved line or part of a circle stretches from above the Hebrides, passes down through the centre of Scotland, crosses the Mull of Galloway and the Irish Sea to the west of the Isle of Man, enters Ireland and makes its way across its south-eastern corner to the Atlantic; this isobar indicates a pressure of 29·1 inches, or $\frac{2}{10}$ths greater than within the centre of the depression. The next isobar, still further to the East,

stretches from the Shetlands, across Durham and Cardigan Bay to the north of Pembroke to the Atlantic; it has a pressure of 29·3. The fourth isobar, 29·5, crosses the Wash and trends in a south-westerly direction through the Midlands, and finally reaches the English Channel through Devonshire on its way to the Atlantic. The fifth isobar, 29·7, crosses

THE WEATHER.

METEOROLOGICAL REPORTS.

Weather Chart, Tuesday, Aug. 25, 6 p.m.*



the neck of Denmark, and has a course through the Straits of Dover, along the English Channel and across the north-west of France to the Atlantic; and the sixth and last isobar, 29·9, extends from the east of France across the Bay of Biscay to the north-west of Spain; the difference between

* *The Times*, Wednesday, August 26th, 1891.

the first and sixth isobar being exactly one inch, 28·9–29·9; therefore the chart shows a crowded array of lines (isobars), each differing, as regards barometric pressure, $\frac{2}{10}$ths of an inch from the one next to it, and when this occurs the distances between the lines are lessened and the *gradients* are said to be "steep," the same term that the engineer uses when describing an area on which the contour lines lie close together, as over steep precipitous hills, etc. For the above "weather chart" I am indebted to the kindness and courtesy of the proprietors of *The Times*.

Every school-boy does not know what a contour line is; but in my opinion he should be taught, at least before leaving school, whatever his future lot in life may be. Rather than give my own definition of this useful sign in physical geography, I will append the one given by Mr. W. Henry Penning, F.G.S., a geologist in H. M. Geological Survey of England and Wales, in his excellent text book of "Field Geology," published by Baillière, pp. 8–25, where he says:—

Contour Maps.

Some maps have marked on them certain lines, the meaning of which it is well to clearly understand, and which are called "contour lines." These lines convey at a glance, to the eye accustomed to them, the physical geography, or the actual shape, of a part of country, its hills and valleys, its precipices and ravines; not merely in a sketchy or approximate form, but with heights and depths taken from actual admeasurement. For a contour line runs through all the points at which a perfectly horizontal plane at a given height would intersect the surface of the ground; or, in other words, if the land were covered with water to a certain height, the margin of the water would be exactly represented by a contour line drawn at the same elevation.

This we can illustrate by the map before us, thus: If the sea were to rise above its ordinary level to the extent

of 250 feet, then all the land in the Cumberland and Lake District coloured *dark-blue* would be submerged, and the line of high-water mark for this 250 feet rise would represent the contour line for that height. If, however, the sea continued to rise until it reached 500 feet, then the land coloured *light-blue* would be submerged, and the line of high-water mark would correspond with the 500 feet contour. Again, if another rise took place of an additional 500 feet, then would all the land coloured *light-brown* be under water, and the area instead of being continental as it is now, would be split up into a number of islands, and the high-water mark of this third rise of the sea would correspond with the 1,000 feet contour lines, above which appear the *dark-brown* insular masses which remain above water, in consequence of the land which constitutes the mountain system of this area being above the 1,000 feet contour line. With these *dark-brown* masses we shall begin our description of the "Contour Map," but before doing so it will be well to add what Mr. Penning has further to say on contour lines.

These lines, he says, are shown for every 10, 20, 50 and 100 feet, according to the scale of the map and the degree of accuracy required. In geological surveying they are of assistance in the drawing of boundary lines, whether of horizontal or inclined strata, in ascertaining heights with accuracy, where they run, and between them by estimation. Observed in relation to boundary lines, the contours indicate the direction, and in some measure the amount of dip of the beds, and are otherwise useful in making various calculations.

The scale of the contour map that we are now discussing, being only 12 miles to the inch, is too small for displaying more contour lines than have been given without running the risk of overcrowding and confusion. For instance, if we take the *Black Combe* mountain mass to the S.W. of the area in the Bootle district, we find there are only three contour lines between the *dark-brown*, and the line of high-water mark

indicating 250, 500 and 1,000 feet respectively; within, however, the same distance on the Ordnance Survey ("New series") maps, on a scale of one mile to the inch, there are ten contour lines including the one of the 1,000 feet level, or one for every 100 feet. On maps having a scale of one mile to every 6 inches, it is possible to draw lines at every 25 feet and even at every 10 feet; and on the large parochial maps on the 25-inch scale at every one or two feet rise in the level, so as to render such maps admirably adapted for sanitary purposes, as for calculating the slope of the land for drainage and other engineering purposes, such as railways. These contour lines are of essential service in agriculture, as they aid the farmer in selecting the proper aspects for his crops; so essential in wheat culture, as proved in my investigations on the effect of aspect on the wheat-yield of Great Britain; the results of which I gave in two lectures, delivered in London in July, 1886.*

Contours, Mr. Penning further adds, run in a V-like shape up the valleys, in lines more or less straight on flanks and ridges, and sweep round the outline of the hills; their variations are as numerous as the hills themselves, but these kinds of form prevail in all. It is but seldom, however, that a valley presents a straight line, it follows rather a serpentine course; therefore a contour, at or near its entrance, would be like a V with both its sides slightly curved in the same direction.

To this explanation of the three principal forms of contour lines it will be well to add a few remarks and illustrate them by the contour map before us. In the first place the sharp point of the V, or the point where the two sides of the letter meet at an acute angle, in the case of valleys that have been

* "The Effect of Aspect and Climate on the Wheat-yield in England." Reported in *The Times*, August 14, 1886; *The Farmer and Chamber of Agriculture Journal*, August 9, 1886; *Bell's Weekly Messenger and Farmer's Journal*, August 23, 1886.

formed by flowing water, either in recent times or at periods more remote, always points *upwards* towards the *higher* land, so that on the *north* side of the great Transverse Ridge the V-like contours would more or less be seen to assume the usual position of this letter when printed. Thus the rivers *Wampool* (Wigton), *Caldew* (Carlisle), *Petterill* and *Eden* (Penrith), are seen to lie in loop- or V-like channels of *dark-blue*, the *apices* of which are directed towards the *high* ground of the central transverse ridge of mountains, whilst their *bases* or broader parts open towards the *lower* ground; the valleys, in fact, are *funnel-shaped*, the broad parts of which look towards the sea or lowest ground.

If we now examine the part of the area to the south of the transverse ridge, we shall see four loop- or V-like valleys in the Kendal District, coloured *light-blue*, in one of which, the second from the west, the river *Kent* is represented; in the others the becks have been omitted.

The most western of the four, having its broad end opening on the north-east of Windermere Lake, is the valley of the *Troutbeck*, one of the affluents of the lake; its apex points to the high ground of the great central water-parting, (transverse ridge), where the loop is repeated in the *light-brown* inter-contour space, and made conspicuous by the *dark-brown* of the high ground of the 1,000 feet contour-line, where Caudale Moor (2,214) lies, into the southern side of which the source of the *Troutbeck* has scooped the head of the valley, about 1½ *miles* north-east of Kirkstone Pass. To the east of *Troutbeck* is seen the group of *light-blue* loops forming an irregular trident; these are the valleys of the sources of the river Kent; in the most western the river *Kent* is seen to take its course, the loop is Λ-shaped, but the letter is reversed, although, as in all other cases, the apex points to the high ground and the base to the lowest. This light-blue loop like that of Troutbeck is seen to be capped by a light-brown inter-columnar space, the apex of which contains the

Kentmere reservoir, and points to the high ground above it where lie *Lingmell End* (2,183), to the south-west of which are the well known features in the sky-line, *Froswick* (2,359), and the pyramidal *Ill Bell* (2,746). To the east of the *Kentmere* loop is the centre prong of the trident. This is the valley of the *Sprint*, coloured *light-blue*, and above it is seen the long *light-brown* valley of *Long Sleddale*, having its apex pointing towards the elevated mass of *Adam Seat* (2,180), and the *Knowe* (2,509). The easternmost prong of *light-blue* is the valley of the *Mint*, which is similarly capped by a *light-brown* inter-contour loop, reaching high up into the *dark-brown*, where the sources of this tributary of the *Kent* take rise from the southern flanks of *Bannisdale Fell*. These illustrations will suffice for the present, as in the course of the description of the other features of this map, attention will be drawn to similar examples, an abundance of which are to be found in this wonderfully beautiful area.

Now whilst it has been seen that the *apices* of the valleys point to the high ground, it must have also been observed that the contour "sweeps round" the outline of the hills or *high* ground; and that in doing so also forms loops, the apices of which point in an opposite direction—towards the *low* lands. Let us take the elevated mass with which we commenced, the elevated mass in the Bootle district, characterized by Black Combe in the south-western part of this area: here we observe the south-western part of the *dark-brown* pointing to the sea; and that this V-like extension is succeeded by a similar *light-brown* loop, and this again by the *light-blue loop*, rendered conspicuous by the *dark-blue* of the low land bordering the coast. If we now retrace our steps to the Kendal district we shall find similar features illustrating this fact, in the high lands that separate the valley of the *Troutbeck* from that of the *Kent*, and this valley from *Long Sleddale*, and the latter from the vale of the *Mint*.

The *dark-brown* tongue of high land between the *Troutbeck*

and the river *Kent* is seen to point southward or towards Windermere; it has its base at *Froswick*, and its apex at *Applethwaite Common;* and is succeeded by the *light-brown* area pointing in the same direction: in fact the lower end is somewhat bifid, owing to the course of a small streamlet which feeds the *Kent*, falling into it at *Staveley*. On the sharp eastern point lies *Orrest Head* (784), above Elleray, near the Windermere station, whence the most magnificent view in the whole area of the Lake District can be seen. That little point is classic land; for it was the abode of Professor Wilson (Christopher North), and the delight of the most refined and cultured minds, among whom were the Coleridges, father and son, Southey, Wordsworth, De Quincey, Mrs. Hemans, and a host of other lovers of nature, whom the beauty of this spot had so oft inspired.

The long extension of elevated land coloured *dark-brown*, between the valleys of the *Kent* and *Sprint*, points to the south-east, and so does the *light-brown* inter-contour V-like loop. This tongue of heights stretches from *The Knowe* (2,509), and *Raven Crag* to *Potters Fell*, and includes between these extreme points *Sleddale Forest*, from which the valley of the *Sprint* takes the name of *Long Sleddale*. In the next chapter the geological structure of this ridge will be described from a section by Mr. W. Aveline, F.G.S.

Between *Long Sleddale* and the valley of one of the principal sources of the river *Sprint*, *Bannisdale Beck*, is seen a pointed promontory of *dark-brown*, pointing to the S.E., and succeeded by a loop of *light-brown* having the same direction. This mass of high land stretches from *Bannisdale Fell* (1,819) to Whiteside Pike (1,301), and includes Capplebarrow (1,683).

Mr. Penning remarks that contour lines are more or less straight on the flanks and ridges of hills, of which the map under discussion affords a good example in the 1,000 ft. line, which forms the south-western boundary of the largest *dark-brown* area in the whole of Cumberland and Westmorland.

This line may be said to extend in a south-easterly direction, from the southern part of the *Brampton* district (close to the letter R of that name) near *Castle Carrock*, to the V-like loop in the *East Ward* district, which is repeated by the larger loop of the *crimson* line representing the great water-parting of the North Pennine Chain; a distance of over 30 miles. The terminal loop just mentioned is the head of the valley which gives passage to one of the principal sources of the river *Eden*, *Argill Beck*, which has its origin in *Stainmoor Forest* (1,582).

This contour line further illustrates also the upward looping of valleys and the downward looping of the heights. The south-west boundary of the North Pennine *dark-brown* mass is seen to be notched or irregularly serrated along its course: the *light-brown* notches or loops represent the valleys of the numerous tributaries of the *Eden*, whilst the *dark-brown* tooth-like projections between them indicate the positions of the high ground separating the valleys.

The Principal Mountain Masses of Cumberland, Westmorland, and the Lake District.

These are distinguished on the "Contour Map" by the *dark-brown* colour indicating all land above the 1,000 ft. contour line.

Within the Lake District there are four principal masses: two forming the great transverse ridge, which lies between the northern and southern masses of *Skiddaw* and *Black Combe* respectively.

Outside the Lake District there are two masses above the 1,000 ft. contour, but these belong to the same mass, the North Pennine Chain. They are naturally connected both geologically and by continuity of water-parting, as the *crimson* inland boundary line of the North Pennine Chain shows. These masses may be classed under the following heads:—

Within the Lake District: I. *The Scafell;* II. *The Helvellyn;* III. *The Skiddaw;* IV. *The Black Combe;* and outside the Lake District, V. *The Bewcastle;* and VI. *The Edenside.*

These six masses will be considered as centres of certain smaller masses which will be treated as physical or geological outliers, as the case may be.

I. *The Scafell.* This mountain mass lies in the western part of the Lake District between the *Helvellyn* mass and St. Bees' Head, and spreads its arms and its climatic influence into the districts of *Cockermouth, Whitehaven, Bootle, Ulverstone,* and *Kendal;* its form is not easy to describe, the readers may, however, see a resemblance to some form that may aid their memories. We must be content to regard it as roughly *stellar* or *radiating;* for its rivers and lakes all more or less radiate from its central line to the different points of the compass. I think if Homer had had to give this mass a name, that the coiner of the epithet "cloud-collector" (νεφεληγερέτα), which he applied to the cloud-collecting Jove, instead of to his Olympian abode, would certainly have been tempted, on looking at this group on the map, to name the *Scafell mountain mass* "the Lake Collector" (λιμνηγερέτα), and in doing so would have truly described it, as will be presently seen.

I. *The Scafell mountain mass* lies to the W. of 3° 4′ W. Long., and between Lat. 54° 20′ N. and 54° 47′ N.; it contains two of the highest mountains in the whole area, *Scafell Pike* (3,210 ft.), and *Scafell* (3,162 ft.): it supplies with water thirteen out of the sixteen principal lakes; and it contains the western portion of the great central water-parting or *Transverse Ridge.*

It may be described as consisting of a central oblong body lying on the northern boundary line of the district of *Bootle,* which separates this district from those of *Whitehaven* and *Cockermouth.* This line will be seen more clearly on the "Geological Map," where it will be found to extend in a S.E.

direction, from just below the N in WHITEHAVEN to the county boundary between Cumberland and Westmorland, at the point where, on the "Contour Map," the July isotherm 60° crosses it. This central mass contains that portion of the great transverse water-parting, which includes the following heights, from N.W. to S.E.:—*Kirk Fell* (2,631), *Great Gable* (2,949), *Great End* (2,984), and *Bowfell* (2,960); so that it has a mean maximum height, along the 4½ miles over which it extends, of 2,881 feet. From this central body rise the sources of the *Lingmell Beck*, the feeder of *Wast Water*, and the river *Esk*, on the south-west; the course of the latter is marked by the loops in the *dark* and *light* blue, and in the *light-brown* inter-contour spaces, the highest having its apex just below E in BOOTLE.

Scafell Pike, *Bowfell*, *Great End* and *Great Gable* are well seen from *Orrest Head*, just above Elleray, whence they are seen to form a part of that magnificent background, which lends such a charm to the view of Windermere from that standpoint.

The Radiating Ridges of the Scafell Mountain Mass.

A little careful study of this mountain mass will not only at once convince the reader that *water* and other atmospheric agents have been the sculptors, that have carved into such grotesque forms its rock-structure, but that, in ages long past, before these agents could have exerted their influence on it, owing to submergence beneath the sea, it must have formed a much more huge rock mass and that it must have been united to the *Helvellyn*, the *Skiddaw*, and the *Black Combe* masses; that in fact their separation has been brought about by water from above in the form of rain, snow and ice, and by water from below in the form of the sea, with its ever restless, pounding, hammering waves. Whilst the whole of this area, comprised within the four divisions, was slowly rising from the sea and escaping the sculpture power of

its waves, it rose into the higher regions of the atmosphere to the extent of thousands of feet higher than the highest point reached to-day; and in doing so attained an altitude where the atmospheric water-vapours, licked up from the sea by the winds, were condensed into snow instead of into rain; and whence the snow, converted by its own weight into ice, gravitated, in the shape of glaciers, along the channels that running water had already carved, before the land had risen above the snow line.

At the present time geologists tell us that we have only the remains of a former enormous thickness of sedimentary rocks and volcanic ashes remaining to tell us the tale of a vast denudation that has levelled a mountain mass equal perhaps in height to Mont Blanc or Etna. The lake valleys that lie within the outstretched arms of rock extending from the central mass just briefly described, are the work of incalculable ages, and the lake-basins themselves are in some instances the result of the gouging power of ice, when impelled forward by the mighty pressure behind, between the sides of valleys that water had originally hewn out of the rock in its torrential course to the sea laden with mud, sand, gravel, and boulders, torn from the riven rocks of the highest peaks.

For the purposes of description the *seven dark-brown* radiating limbs or ridges may be thus briefly named—

1. *The Western* ridge, between *Wast Water* and *Ennerdale.*
2. *The North-western* ridge, between *Ennerdale Water* and *Buttermere*, and *Crummock Water.*
3. *The Northern* ridge, between *Buttermere* and *Crummock Water*, and *Borrowdale* and *Derwent Water.*
4. *The North-eastern* ridge, between *Borrowdale* and *Derwent Water* and Thirlmere.
5. *The South-eastern* ridge, between *Coniston Water* and the valley of the *Duddon.*
6. *The Southern* ridge, between the *Duddon* valley and *Eskdale.*

7. *The South-western* ridge, between *Eskdale* and *Wast Water.*

1. *The Western ridge* contains the extreme western portion of the central water-parting; its form is irregular, resembling somewhat an index hand pointing to the west. On the northern side the contours along the flanks overlooking *Ennerdale* are tolerably straight, whilst the southern border is much indented by the passage of rivers as the *light-brown* inter-contour loops pointing upwards indicate. The first three to the west give passage to the sources of the *Calder*, which can be traced to the corresponding loops in the *light* and *dark-blue* inter-contour areas; the fourth loop belongs to the course of the river *Bleng*, and the remainder have been scooped out by the feeders of *Wast Water.* The *dark-brown* heights between the river valleys are as follows:—The index-finger-like height at the extreme west is *Longbarrow* (*Dent*) (1,130), from which may be traced eastward the water-parting ridge consisting of *Blakeley Raise* (1,276), Grike (1,596), *Caw Fell* (1,500), *Iron Crag* (2,071), *Caw Fell* (2,188), Haycock (2,619), Pillar (2,927), and lastly Kirk Fell (2,631), which we have mentioned before as the point whence the central portion of this mass begins: the main maximum height, therefore, of this portion of the transverse ridge is 1,993 feet. On the south are the following heights from west to east dividing the water-courses from each other:—Lank Rigg (1,750), (*Kinniside Common*), *Copeland Forest*, S.W. of *Caw Fell*, *Scatallan* (2,766), to S. of *Haycock*, and *Yew-barrow* (2,058) overlooking the head of *Wast Water*, and to the S.E. of *Red Pike* (2,629).

2. *The North-western limb* is a long ridge stretching from the central mass near *Brandreth* (2,344), to *Owsen Fell* (1,341), and *Martin Fell* (1,461); the extreme end of this limit is bifid, the former height occupies the northern prominence, and the latter the southern. This ridge separates *Ennerdale*

from the valley in which *Buttermere* and *Crummock Water* lie. This ridge or limb will be noticed again in the chapter on geology.

3. *The Northern limb*, is of large size and not so simple in its form as the last; for it is deeply indented by the sources of rivers. It stretches from the central portion near *Brandreth*, to beyond *Lord's Seat* (1,811) and *Broom Fell* (1,670), both of which form the S.W. background of *Bassenthwaite Water*, when viewed from its right bank. At Broom Fell the ridge turns at right angles to the west, and ends in *Kirk Fell* (1,476). To the north of the crook are seen two outlying heights coloured dark-brown; the smaller western one is the *Burthwaite* height (1,224) rising up from the *Wythop* Moss, which occupies the *light-brown* inter-contour area to the south; the eastern and larger height (1,170) lies to the north of Kelswick Church, and overlooks Bassenthwaite.

This inter-lacustrine tongue of elevated land is an important one, inasmuch as from its north-eastern flanks are derived the numerous tributaries to the river *Derwent*, the *Newlands Beck*, and the lakes they feed; moreover, it overlooks the most noted dale in the district, Borrowdale, so full of interest to all real students of nature. If we take the heights along the line of water-parting from *Brandreth* (2,344) to *Lord's Seat* (1,811) we shall be better able to estimate the importance of this ridge.

Next to *Brandreth* is *Grey Knotts* (2,287), which lies to its north, then comes *Dale Head* (2,473), *Robinson* (2,417), *High Smell Rigg* (1,725), *Knott Rigg* (1,772), *Sail* (2,500), *Eel Crag* (2,649), *Sand Hill* (2,525), *Grisedale Pike* (2,593), the *Turnpike Road* to Branthwaite across the neck of the crooked extremity (above 1,000 feet), *Combe Plantation* (1,627), and lastly, *Lord's Seat*, the extreme point of the ridge to the north (1,811); which heights give a mean maximum level of 2,147 feet along the water-parting of this northern limb, which at a height above the 1,000 feet level stretches over 12 miles.

From the south-eastern side of this limb will be seen projecting from the main mass a very pointed tongue of land directed towards the north, coloured *dark-brown*. This ridge separates Borrowdale on the east with the Derwent River and part of the Lake, from the valley of *Newlands Beck*, which falls into Bassenthwaite Water to the south-west of the river *Derwent*, the connecting link between Derwent Water and Bassenthwaite. This sharp tongue extends north for about 3½ miles from Dale Head above the 1,000 feet contour, and its ridge (beginning from the south) is made up of *Eel Crags* (2,143) through *Maiden Moor* (1,887) to the base of the sharp point *Cat Bells* (1,482), near the site of the *Brundelhow* lead mines.

4. *The North-east ridge* between *Borrowdale* and *Derwent Water* on the west, and *Thirlmere* on the east, has now to be considered. This mountain-mass springs from the central portion between *Allen Crags* (2,572) and *Bow Fell* (2,960). Between the main portion of this mass and the one just described will be seen a small *dark-brown* projection pointing in a north-easterly direction, and lying between two loops of *light-brown*. This mass has at its base *Allen Crags*, a little to the north of the main central water-parting, and the bifid head of the valley contains in the western loop the source of the river *Derwent*, whilst the one to the east contains the *Longstrath Beck*, which joins the main river about half-a-mile to the north-west of the village of Rosthwaite, the *Borrowdale Fells* lying, as it were, in the fork of the two valleys. This minor mass has a total length above the 1,000 feet contour of about 3¼ miles, and a mean maximum height of 2,469 feet, excluding *Allen Crags;* on this tongue lie *Glaramara* (2,560) and *Rosthwaite Fell* (1,807).

We now come to the main mass. From the point of origin at *Bow Fell*, which lies on the great central transverse water-parting, to the Pike at the extreme north of *Castlerigg Fell* (1,177), the ridge has a length of a little over 11 miles,

and a mean maximum height of 1,932 feet. The following mountains lie upon it, excluding *Bow Fell; Rossett Crags* (2,106), *Black Crags* (1,922), *High Whitestones* (2,500), *Greenup Edge* (2,081), *Ullscarf* (2,370), *Long Moss* (1,750), (below which lies *Blea* Tarn, at a height of 1,562 feet), *Armboth Fell* (1,588), High Seat (1,996), *Bleaberry Fell* (1,932), and *Castlerigg Pike* (1,177).

The principal valley loops are on the western side; one of which gives exit to the *Watendlath Beck*, an independent feeder of Derwent Water, to the west of which is the *dark-brown* projection of *Grange Fell* (1,250), on which also is *Brund Fell* (1,363), and on the eastern side the nose-like *dark-brown* projection lying on the water-parting and county boundary to the west of *Dunmail Raise* (781), is *Steel Fell* (1,811). On the chin-like projection to the south of *Steel Fell* is *Silver How* (1,345), dividing the valley of the river *Rothay* on the north-east from that of *Great Langdale Beck* on the south, which after passing through Eter Water, where it is joined by *Little Langdale Beck*, the combined waters issue as the river *Brathay*.

Between the ridge (4) just described and the next in succession (5), there are the remains of another important mass of elevated land lying between *Windermere* and *Coniston Water*, but not of sufficient height to be included, except over a very small area, at *Long Crags*, within the 1,000 feet contour. This elevated ground is represented by the *light-brown* masses and their flanks coloured *light* and *dark-blue*; they form the *lower* part of the background, of which Coniston Old Man and the mountains on either side from *Furness Fells* to the Langdale Pikes form such a glorious and distinguished feature when Windermere is viewed from the east.

The elevated land about to be briefly described lies between *Windermere* and *Coniston Water*, and apparently at the foot of the giants behind, when viewed from Orrest Head, or the road between *Troutbeck* Bridge and Bowness, whence they

appear in the following order from south-west to north-east; *Black Combe* (1,969), *Caw* (1,735), the highest point of *Dunnerdale Fells*, the extreme south-west point of the next ridge (6), *Walna Scar* (2,000) with *Brown Pike* (2,239), *The Old Man of Coniston* (2,633), *Ridge of Seathwaite Fells* (2,500), which end in the precipitous peak, *Carrs* (2,500), lying to west, and dipping down behind the next height, *Wetherlam* (2,250); the sky-line then dips to the *col*, on which the *Three Shires Stone* stands, the *Wrynose Pass*, on the eastern side of which the river *Brathay* rises, and on the west the river *Duddon*; from this depression we trace the line against the sky until we reach *Great Knott* (2,259), and then the *Pike of Bliscoe* (2,304) and the *Crinkle Crags*, whence the ridge slopes, until it again rises towards the next mountain, *Bow Fell* (2,960), between which and the *Crinkle Crags* the highest point in England is seen, *Scafell Pikes* (3,210); then we get a glimpse of *Great End* (2,984), *Great Gable* (2,949), *Glaramara* (2,560), and lastly the *Langdale Pikes*, the *Pike of Stickle* (2,323), and *Harrison Stickle* (2,401).

Such was the glorious mountain view that stood out clear, distinct and purple against the ruddy golden sky of a setting sun on the 21st September, 1885, the date of my first visit to Orrest Head; the purple of the peaks merging into the dark-green of the foliage of the lower heights of *Hawk's Head* and *Claife Heights*, which seemed to lie humbly at their feet, whilst the broad waters of the lake, like an inland sea of molten silver, reflected their solemn beauty, and thus enhanced the glory of one of nature's grandest displays of brilliant colour and perfect form, never to be forgotten.

The lower heights separate *Windermere* from Coniston Water. The small light blue outlier close to the lake is the *Claife Heights*, and between it and the *light-blue* and *light-brown* heights, to the west lies *Esthwaite Water*, whilst still further to the west is seen a forked area of *light-blue* surmounted by a ridge of *light-brown*, the northern part of

which is *High Arnside* and *Hawk's Head* moors; the southern or bifid portion contains the *Furness Fells*, characterized by *Long Crags* to the west, and *Great Green Howe* to the east.

5. *The South-east ridge*, between *Coniston Water* and the valley of the river *Duddon.*

This mass has already had many of its features given in describing the distant background of Windermere, so that little more than a few additional details will be required. It may be said to extend from *Bowfell*, where the central portion ends, through a neck-like ridge, on which are *Shelter Crags* (2,651), *Long Top* (2,816), and *Great Knott* (2,259), to the main mass, which begins at the *col*, on which *The Three Shires Stone* stands, between the sources of the rivers *Brathay* and *Duddon*, the *Wrynose Pass;* thence it extends in a more or less southerly direction through the following heights:—*Hinning House Fell* (2,537), *Seathwaite Fells* (2,500), *Brown Pike* (*Walna Scar*, 2,239), *The Old Man of Coniston* (2,633), *Caw* (1,735), the highest point of *Dunnerdale Fells;* the total length of which from *Bowfell* to the extreme point of the 1,000 feet contour line being 11 miles; whilst the mean maximum height amounted to 2,457 feet. The great valley-loop of the *Duddon* separates this ridge from the next one on the west, and that of the river *Brathay* on the east. *Lingmoor Fell* (1,410), an outlier not shown on the maps, divides the *Great Langdale Beck* from the *Brathay*. Through the loops below this river issue the feeders of Coniston Water.

6. *The Southern ridge*, between the Duddon Valley and Eskdale.

This is altogether narrower than the limb just described. It curves to the south-west, and may be described as having its base at Bowfell and winding through Yew Bank (1,570), Border End (1,803), Harter Fell (2,140), Ulpha Fell (1,336), to Great Worm Crag (1,400), which last height is separated from the great mountain mass of Bootle, of which Black-

Combe is the dominant height, by the valley through which Crosby Gill flows, coloured *light-brown* in the map; this gill falls into the *Duddon.* From Bowfell to the extreme point of the 1,000 feet western line along this ridge, the distance is between 7 and 8 miles.

7. The *South-western ridge*, between *Eskdale* and *Wast Water.*

This ridge has its origin in that great mountain mass known as Scafell; of which *Scafell* proper has an altitude of 3,162 feet, whilst Scafell Pike exceeds this height, being 3,210 feet; the Scafell mass would occupy the position of the letter E in the name of the district of BOOTLE. This rounded mass projecting to the south-west is separated from the remainder of the ridge by a depression in which *Burnmoor Tarn* lies (832 ft.), and the road that crosses the pass into Wasdale. The Scafell portion of this ridge contains the loftiest mountain in England; besides which, it contains many rock masses of great height, so that this portion of the elevated ground, estimated by the height of its twelve principal summits, has a mean level of 2,334 feet. The *col* already mentioned separates the *Scafell* mass from that of *The Screes*, lying to the south-east of *Wast Water.* This south-westerly termination of the ridge has its axis from south-west to north-east, and presents the eminences of *Ill Gill* (1,978) to the N.E. and *White Rigg* (1,755) to the S.W.

The Scafell portion of this south-western mass is bounded at its north-east by the remarkable depression known as *Esk Hause*, which lies to the north-east of the great transverse water-parting. Along this hause or throat there is a mountain road from Wastdale to Langdale; near this road lie, at the north-western portion, *Sprinkling Tarn* (1,960), and *Sty-head Tarn* (1,430), which derive their waters from the sides of *Allen Crags* (2,572), and then empty them into the river Derwent in Borrowdale; from the south-west of Allan Crags there proceeds in a south-westerly direction a ridge or

minor water-parting, which crosses the great transverse central water-parting and connects the *tongue-like* mass (described under *the north-east ridge* (4), characterized as supporting Glaramara, and lying between the bifid head of Borrowdale), with the Scafell mass. This minor ridge has on its south-eastern side, *Angle Tarn*, lying on the flank of *Hanging Knott* (2,903); it empties its waters into the sources of the Langstrath Beck, which, after pouring down Longstrath, joins the river *Derwent*, so that at their origins the two heads of the *Derwent* rise on opposite sides of this minor water-parting, but meet in Borrowdale. This *south-western ridge* (7) is separated from the *western ridge* (1) by *Wast Water*, and completes the seven radiating ridges of the *Scafell mountain mass.*

Recapitulation.

The details that have just been given in describing the form and constitution of the above seven ridges radiating from what has been termed the *Scafell Mountain* mass, however useful for reference, can hardly be expected to be remembered.

It will perhaps, therefore, be well to give a short recapitulation of the main facts connected with these seven ridges, in order to aid the memory in retaining what is essential. All the *ridges* are coloured *dark-brown* on the " Contour Map."

1. *The Western Ridge* between *Wast Water* and *Ennerdale, Water* has been compared to an index-hand pointing to the west (St. Bees' Head). The extreme western point is *Blakeley Raise* and the high ground is extended through *Grike* and *Pillar* to *Kirk Fell.* The southern flanks are indented by the sources of the rivers *Calder, Irt,* and the affluents of *Wast Water ;* whilst the *heights* dividing these sources are from west to east, respectively, *Lank Rigg, Caw Fell, Scatallan,* the most southerly and extensive, and *Yewbarrow:* the two last lying immediately to the north-west of *Wast Water.*

2. *The North-western Ridge*, between *Ennerdale Water*, and *Buttermere* and *Crummock Water*. This is a long mass terminating in a bifid manner towards the north-west. The chief components of this ridge, beginning from the extreme north-west, are *Owsen Fell*, *Gavel Fell*, *Starling Dodd*, *Red Pike*, *High Stile*, *High Crag*, to *Brandreth*. The southern extreme point of the bifid end is *Murton Fell*. Within the loop between the two extreme north-westerly points are some of the sources of the river *Murton*, a tributary of the *Derwent*. On the northern flanks rise the affluents of *Lowes Water*, *Crummock Water*, and *Buttermere*.

3. *The Northern Ridge* between *Crummock Water* and *Buttermere* and *Borrowdale* and *Derwent Water*.

This is one of the most considerable mountain masses—it terminates in a sort of *crook* to the north, having still further north two outliers: is deeply indented on the eastern side, and is characterised by a sharp pointed ridge springing from its base, and pointing to the north.

Its main ridge proceeding from the extreme point of the crook consists of *Kirk Fell* (not *the* Kirk Fell) to *Lord's Seat*, *Grisedale Pike*, *Sand Hill*, *Eel Crag*, *Robinson*, *Dale Head*, to *Brandreth*. The sharp-pointed ridge lying between *Borrowdale* and *Newlands*, consists of *Cat Bells* at its extreme north, through *Maiden Moor*, to *Eel Crags* in the south. The loops in the crook give passage to some of the sources (*Whit Beck*) of the river *Cocker*; whilst the western flanks are indented by the affluents of *Crummock Water* and *Buttermere;* and the eastern are deeply sculptured by the main sources of *Newlands Beck*, one of the chief affluents of *Bassenthwaite Lake*. The pointed spit of land separates *Newlands* from *Borrowdale*, with its river and *Derwent Water*.

4. *The North-eastern Ridge* between *Borrowdale* and Derwent Water and *Thirlmere*, is an irregular mass somewhat pointed to the north. It consists of the following heights from north to south, namely, *Castlerigg Fell*, *High Seat*,

Ullscarf, *High White Stones*, *Thunacar Knott*, and *Pavey Ark*, to *Allen Crags ;* from which last also springs a promontory of high land that divides the bifid head of Borrowdale and on which lies *Glaramara.* From the western side of the main ridge issue the affluents to *Derwent Water ;* and from the eastern the affluents of *Thirlmere* including the *Wythburn*, the most southerly; and others of less importance which empty their waters into the left side of the lake. The most north-easterly indentation gives passage to the source of the *Naddle Beck*, which eventually falls into the river *Greta.*

5. *The South-eastern Ridge*, which separates *Coniston Water* from the valley of the *Duddon*, is an elongated, pear-shaped mass, extending from *Bowfell* through a neck of land to the main mass extending south to *Dunnerdale.* It is characterized by the two well-known mountains, *Coniston Old Man*, and *Wetherlam.* At the point where the neck joins the main mass is situated the *Three-shires Stones.* At its extreme north is *Bowfell*, which is succeeded towards the south by *Great Knott*, *Pike O'Blisco*, *Wetherham*, *Coniston Old Man*, *Walna Scar*, and *Dunnerdale.* On both sides it is deeply indented ; on the west side by the river *Duddon* and its tributaries, and on the east by the *Langdales*, and the rivers which flow through them to supply Windermere and other water masses. Below the *Langdales*, to the south, the mass gives egress to the affluent waters of *Coniston.*

6. *The Southern Ridge*, between the valley of the Duddon and Eskdale, is a long but comparatively small mass. It has its base at *Bowfell*, from which it stretches through *Harter Fell*, to *Great Worm Crag* and *Ulpha Fell ;* on its east side it is scooped out by the tributaries of the *Duddon* and on the west by those of the river *Esk.*

7. *The South-western Ridge*, between *Eskdale* and *Wast Water*, is the highest of all the radiating ridges. It extends from Esk Hause to the far extreme south-west point of the *Screes.* It is notable as containing the *Scafell* mass, which

is separated from the *Glaramara* mass at the head of *Borrowdale* by *Esk Hause*, and from the *Screes* mass, by the depression over which the road to Wasdale crosses, and *Burnmoor Tarn* lies. It is deeply looped by the tributaries to the river *Esk*, and by the affluents to Wast Water.

II. *The Helvellyn Mountain Mass.*

This great division of the Cumberland and Westmorland mountain masses is separated from the *Scafell* mass (I.) by one of the most interesting and thickly populated depressions in the whole mountain and lake area, which it well be well to describe first.

The Central Depression of the English Lake District.

This great central depression of the English Lake District may generally be described as extending from the mouth of the river *Kent*, where that river empties its waters into Morecambe Bay, in a more or less north-westerly direction, over *Dunmail Raise* (783), its highest point, and that portion of the great central transverse water-parting which forms the link between the two great mountain masses of *Scafell* and *Helvellyn;* it then descends into the vales of *Wythburn* and *Thirlmere*, and after pursuing a north-westerly direction through Keswick, it may be traced along the course of the river *Derwent*, and *Bassenthwaite Lake* to the sea at *Workington.* During this course it only traverses two registration districts, *Kendal* and *Cockermouth.*

The "*Contour Map*" will enable us to trace the course of this depression: beginning at the mouth of the river *Kent* we follow it in the *dark blue* until after the town of *Kendal* is passed; the road then turns to the north-west and gets into the *light blue* around the northern portion of an elevated area, coloured *light brown*, to the west of the letter S in Westmorland. This height, on the eastern side of its upper and broader end, is characterised by *Kendal Fell* (650), whilst

to its extreme north is *Plumgarths Fell* (679), under which the road lies; to the south of these eminent scars, on the same *light blue* area, rises *Scout Scar* (713), and still further south, at its extreme sharp end, the scar that overlooks the road just before reaching *Brigsteer*, has a height of 505 feet. *Scout Scar* commands a splendid view of the Lake mountains; but what will interest the geologist most is the oblong *light blue* height to the south-west, and to the west of the letters W and E of the name of the county. This tract of elevated land is the mountain-limestone outlier of *Whitbarrow*, where the huge tilted slabs of the above formation are sculptured with the most grotesque forms; the result of nature's etching acids—the carbonic acid of rain-water, and the still stronger corrosives, resulting from vegetable and rock decomposition. From the post-glacial *drumlin*, on which Kendal Castle is built, a good view of the *Kendal Fells* and *Scout Scar* can be obtained, and should the observer be fortunate enough to witness the sun set behind them about midsummer, he will see the great orb of day as it were rolling down the sky-line of the slope of the fells, until hidden altogether; just as the writer has seen it apparently roll down the sky-lines of the flanks of the Grampian *Bens* to the west of *Stuc-a-chroin* (3,189), from the *Abbey Craig* near *Bridge of Allan*.

Resuming our journey, we pass under the height of *Plumgarths*, and proceed to the north-west until we reach the narrow strip of *light blue* lying between a projection of the main mass of *light brown* to the north, and a somewhat quadrangular mass of the same colour to the south; the boundary of the *northern* mass is the termination of the southern slopes of *Hugill Fell* (839), at *Ravenscar*, Staveley, on the east, and of *Orrest Head* (871) at *Bannerigg* on the west. On the southern mass lies *Crook Common*, the northern portion of which rises to the height of 818 feet at *Borwick Fold*. Between these two heights lies the *light blue* valley,

through the eastern part of which the river *Gowan* flows on its way to join the *Kent* at Staveley: whilst the western portion is watered by a streamlet that enters *Windermere* Lake just north of *Bowness*. The concavity in the southern boundary of the northern *light brown* mass shows the point where the river *Gowan* enters the valley after rising on *Applethwaite Common* to the south of *Sour Howes* (1,568). The extension line to Windermere of the Lancaster and Carlisle Railway from Oxenholme station runs through this valley. On reaching the village of Windermere, we again bear to the north-west, passing the classic heights of *Elleray*, with its wide-spreading sycamore, overshadowing the once happy home of John Wilson, known throughout the civilized world, not only by his own name, but as "Christopher North": a man whom nature had endowed with a powerful mind and a powerful body, united by a loving heart that ever guided its companion powers. With a host so genial, manly, and cultured; whose love for nature knew no bounds, and whose readings and interpretations of her were so fresh, joyous, and true, it was not to be wondered that his humble abode became the *focus*, in the true sense of the term, to which all who took nature as their guide, and devoted their best powers to understand her, would gather; Scott, Wordsworth, Coleridge, De Quincey, Hartley Coleridge, besides a host of others, were those who sought the companionship of such a man, and were never tired of the lovely views of lake and fell which Elleray commanded, nor of mounting to *Orrest Head* with their host, and there listen to his loving admiration of all that surrounded them; content for once to let their silent praise mingle with his eloquence.

This is a digression from the valley to the height, which, however, I advise every traveller to make.

In the valley once more we proceed along the road to *Ambleside*, our way lying by the lake on the *dark blue* tint; shortly we cross the *Troutbeck Bridge*, at the base of the *light*

blue loop, pointing up the valley of the *Troutbeck*, which has its source high up on the southern flanks of *Caudale Moor*. At Ambleside we cross the mouth of another loop that gives exit to the waters of *Stock Gill*, having its source near *Kirkstone Pass*. Immediately succeeding this loop are two others, through which flow respectively *Scandale Beck*, from the dell of the same name, and *Rydal Beck*, which latter has its source at *Rydal Head*, between *Fairfield* (2,863), and *Hart Crag* (2,698). *Rydal Beck*, *Scandale Beck*, and *Stock Gill*, all cross the road below *Rydal Water* (181) to join the river *Rothay*. As we advance along we have the left bank of *Rydal Water*, and on *our* right hand *Nab Scar*, and *Nab Cottage* by the roadside, where Hartley Coleridge lived. Beyond this point the road turns sharply round a nab (White Moss, 460) where was the "Wishing Gate:" we then skirt *Grasmere Lake* (208), after leaving which we have the village of Grasmere and the *Fairfield* spur of *Rydal Fell* (2,022) on our left: during the remainder of our ascent, until we nearly reach *Dunmail Raise*, the river *Rothay* flows down on our left, after crossing the road near the county boundary, from its source near the top of *Dollywaggon Pike* (2,810), a prominent height along the ridge of the *Helvellyn* mountain mass. At *Dunmail Raise*, the depression or valley we have been following attains its greatest altitude, 783 feet. Here we may rest awhile and refer back to the description of the view from *Orrest Head*, whence can be seen *Steel Fell* sloping down on the west towards the pass of *Dunmail Raise*, which has as its eastern boundary *Seat Sandal* (2,415). This view will be again referred to in the chapter in which the geographical distribution of heart disease is discussed, as it affords a remarkable illustration of the effect of the physical configuration of the land on medical geography.

The county boundary between the shires of Cumberland and Westmorland crosses the road over *Dunmail Raise*, on reaching it from *Steel Fell*, and then ascends on the eastern

side up the northern flank of *Seat Sandal*, along the course, for a short length, of the mountain stream known as *Raise Beck*, and as the source of the river *Rothay*, already referred to as having its origin near the summit of *Dollywaggon Pike*, to the north of *Seat Sandal*. The exact position of this portion of the great transverse water-parting is indicated on the "Contour Map" by the dotted county boundary line that crosses the narrow *light brown* pass between the *dark brown* nose-like prominence projecting from the *Scafell mountain mass* (I.) on the west, *Steel Fell*, and the rounded *dark brown* mass on the east (*Seat Sandal*). It is at this point that the two mountain masses of *Scafell* (I.) and *Helvellyn* (II.) are at the least distance from each other.

We now begin to descend, leaving *Westmorland* and the *Kendal* District at the shire boundary line, to the south of the central transverse water-parting, and entering *Cumberland* and the *Cockermouth District*, lying to the north of that famous ridge, and

> "That pile of stones
> Heaped over brave King Dunmail's bones;
> He who had once supreme command,
> Last king of peaky Cumberland,"

as Wordsworth notes it in his "Waggoner."

On reference to the "Contour Map," it will be seen that the depression—as it is continued between the *north-eastern dark brown ridge* of the *Scafell* mass (I.), and the *northern dark brown ridge* of the *Helvellyn* mass (II.)—has a pretty uniform breadth, as regards the space between the 1,000 ft. contours of its lateral boundaries; at the northern end of *Thirlmere* (533), these two *dark brown* masses recede from each other, and still further to the north (where the effluent of the lake, *St. John's Beck*, is seen to be diverted from the northerly course, and to turn, soon after receiving the lake's waters, towards the east), they are separated by an elevated mass, not shown on the map, but situated on the

light brown, and crossed by the words *Derwent* and *Water* in separate lines. This mass is known as *High Rigg*, or *Naddle Fell*, and rises to the height of 1,163 feet at *Rake Howe*; it is continued in and to the west of the crook of *St. John's Beck*, from *High Bridge End*, where the stream turns to the east, to the north of *Rake Howe*, and then turns to the west, before going northward to *Threlkeld Bridge*, where it joins the *Glenderamackin*, or upper portion of the river *Greta*, which has its source in the *Skiddaw* mountain mass (III.), as well as on *Matterdale Common*, at the extreme north of the *Helvellyn* ridge.

Instead of following the course of the *St. John's Beck*, as above indicated, we shall now pursue the central valley on the western side of *Naddle Fell*, after reviewing some of the points that we have passed unheeded in the general description just given. In the first place, after leaving *Dunmail Raise*, we have the valley of the *Wytheburn* on our left or western side; this chief affluent of *Thirlmere* rises to the east of *High White Stones* (2,500), and to the north of *Serjeant Man* (2,414). The loop of its valley is seen in the " Contour Map " north of the nose-like projection of *Steel Fell*, through which the dotted line of the county boundary is seen to cross towards *Dunmail Raise*. Still further north is another loop for *Dob Gill*, another affluent of less importance; besides which there are seven or eight mountain streams which contribute to the waters of *Thirlmere*, on its left or western side; whilst on its right, or eastern side, only one unnamed and inconsiderable stream reaches it, and that from *Helvellyn* itself; all the others join a stream, *Helvellyn Gill*, which runs by the side of the lower end of the lake, and finally enters *St. John's Beck*, close by the road that we shall take to the north-west in following the valley we are discussing. As we proceed, we have on our left the lake bounded on the west by those heights already described in the *north-eastern ridge* of the *Scafell* mountain mass (I.) (p. 113). On our right and

immediately above us is the ridge of *Helvellyn* itself, but its highest points are hidden from our view by its shoulders. *Birkside, Whelpside* (2,412), *Brown Cove Crags, Whiteside, Watson's Dodd* (2,584), *Calf How Pike* (2,166), and *Clough Head* (2,380), all above us. When we are at the head of *Thirlmere*, at the point where the little stream crosses under the road to enter the lake, we know that we have *Helvellyn* towering above us on our right, at an altitude of 3,118 feet; but we cannot see it, for the shoulders of *Whelpside* and *Brown Cove* hide it from our view. In reference to the remark that Thirlmere only received one insignificant little mountain stream from the north *Helvellyn* ridge, the reader will note how comparatively unbroken by valley loops the 1,000 feet *contour* line of this *dark brown* mass is from *Dunmail Raise* northwards to the point where it breaks to the north-east, just opposite *Naddle Fell.* This unlooped condition of the side of the ridge exposed to the westerly and south-westerly winds is coincident with the protective influence of the *north-eastern ridge* of the *Scafell* mountain mass (I.), and in strong contrast to the deeply looped 1,000 feet contour on the east and north-east side of *Helvellyn.*

We now enter upon the third and last portion of the central depression. Our course lies across *St. John's Beck*, at *Smaithwaite Bridge*, just before it ends its eastern direction, as it winds round the southern base of *Naddle Fell*, between *High Bridgend* and *Low Bridgend* (1,016); we then take a north-westerly direction, and cross the *Naddle Beck*, which has its source at the northern end of the *dark brown north-eastern ridge* of the *Scafell* mass (I), on the flanks of *High Seat* (1,996) and *Castlerigg Fell*, where it has the name of *Shoulthwaite Gill.* This beck we cross, and when doing so, we have *High Rigg*, or *Naddle Fell* on our right, and *Castlerigg* and *Bleaberry Fell* on our left. The road then leads us along the lower and north-eastern end of *Derwent Water*, the lake being on our left or south-western side, and *Latrigg* (1,203)

and the *Skiddaw* mass (III.) to our right or north-east. After crossing the river *Greta*, on leaving *Keswick*, just before it falls into the river *Derwent*, our course takes us along the *dark blue* area at the foot of the crook of the northern point of the *northern* bridge of mass I., *Lord's Seat* (1,811), where we have *Bassenthwaite Lake* between us and *Skiddaw*; we continue on the south-western side of the lake until we find ourselves at the foot of the most easterly of the two *dark brown* isolated heights to the north of the "crook" (1,170), and the lake on our right, backed by *Broad End, Skiddaw Forest.* After this we follow the course of the river *Derwent*, as it changes its north-westerly course to make a semi-circle around the north of *Elva Hill* (788), the *light blue area* in the "*Contour Map*," between which and the elevated mass to its north, coloured *light brown*, *Moota Common* (825), it has made its valley, along which it flows in a westerly direction through *Cockermouth*, and thence to *Workington*, where the great central depression through the Lake District ends. With a few brief remarks we will now sum up what must have struck us on our journey as regards the relation of this long valley to the prevailing winds.

1. From *Morecambe Bay* to *Dunmail Raise*, so far as the south-westerly and southerly winds are concerned, it is freely open to their *air-flushing* influence, which a glance at the "Contour Map" will prove: for it shows that the sea-winds from *Morecambe Bay* are freely admitted up through the valley of *Windermere* and *Coniston*, without any hindrance, and if the map be not sufficient let the reader, when near, mount *Orrest Head*, and thence he will see the gittering waters of the Irish Sea straight before him with nothing to prevent his view.

2. From *Dunmail Raise*, throughout the valley of Thirlmere, these winds are entirely shut out, and when violently blowing would pass over the valley instead of up through it, as they can do to the south of the county boundary.

3. From Keswick through the valley of *Bassenthwaite* the north-west winds would blow up it, but it must be remembered that the heights to the north—*Moota Common*—would frequently divert these winds when not powerful, and break their force when they are so. The latter part of the *Derwent Valley* is open to south-westerly winds from the Irish Sea, and enjoys all the advantages derivable from them.

4. The central depression from *Morecambe Bay* to *Cockermouth* is more or less protected from the easterly and north-easterly winds, even if these winds had not already received a check at the great barrier to the north-east, consisting of the northern portion of the *Pennine Chain*.

The Helvellyn Mass (II.) *Described.*

The *Helvellyn mountain mass*, which is separated from that of *Scafell* by the depression just described, has a remarkable form when plotted on a map at the 1,000 feet level, and coloured *dark brown*, but yet not so remarkable nor so complicated as the *mountain mass I.*

Like that mass it may be divided into a main body and limbs or ridges radiating from it. Taken as a whole, body and limbs together, it is very difficult to define its form; but it may be said to extend from its extreme northern point at *Great Mell Fell* to the east of the 3° W. Long., on which line it continues until the great central water-parting is reached at *Seat Sandal:* after which this ridge is followed in a south-easterly direction until, so far as this mass is concerned, it terminates at *Low Fell* (1,135), from which the river is seen to rise, on the "*Contour Map*" (the *Lowther*), that is further to the north joined by the effluent *Hawse-Water Beck.* The main body may be therefore described as extending from Dunmail Raise to the north-east of *Shap Fells* at *Low Fell*, where the river Lowther rises, and the fell overlooks the *light brown* valley between it and the elevated *dark brown* outlier to the

east, having *Shap Thorn*, *Hardendale Fell*, immediately opposite to it. In the *dark brown* outlier is continued the water-parting ridge, which descends from *Low Fell* to cross the valley named above, through which the Lancaster and Carlisle Railway passes. The body of this mass extending as has been stated along the line of the great transverse water-parting from *Dunmail Raise* to *Low Fell*, consists of the following heights, beginning to the west at *Seat Sandal* (2,416), *Dollywaggon Pike* (2,810), *Rydal Head* (2,863), *Little Hart Crag* (2,091), *Red Screes* (2,541), *Kirkstone Pass* (1,481), *Kirkstone*, *John Bell's Banner* (2,474), *Strong Cone* (2,502), *Roman Road* (2,500), *The Knowe*, *Hart Fell* (2,509), *Adam's Seat* (2,323), *Tarn Crag* (2,176), *Harrop Pike* (1,963), *Great Yarlside* (1,937), *Wasdale Pike* (1,853), and *Low Fell* (1,135); which series of heights, almost in a straight line from west to east gives the body of this mass a mean maximum altitude of 2,203 feet. Such is the *body* of this mountain mass, which may be roughly traced in the "*Contour Map*" along the dotted boundary line separating the district of *Kendal* from those of *Cockermouth* and *West Ward*, until it reaches *Harrop Pike*, immediately south of the *dark brown* ridge that separates *Hawes Water* from the *light brown* valley loop to the south-east, which gives exit to *Swindale Beck*, after rising from the above *Pike*. From this point the body or main transverse water-parting diverges from the boundary line in a direction N.E. by E. to gain *Low Fell*.

The Limbs or Ridges.

From the northern part of the body just described three masses project; a *western*, a *central*, and an *eastern*: between the *first* and the *second* the great *light brown* valley-loop containing *Ullswater* and its affluents lie; whilst between the *second* and the *third*, the *light brown valley-loop* of *Hawes Water* is seen.

(1) *The Western Ridge* has the 3° W. Long. running

through its entire length; its direction is nearly north and south, and it contains the highest mountain of the mass, *Helvellyn*, which, like *Scafell*, is not included in the central transverse water-parting. The length of this ridge above the 1,000 feet contour line amounts to between eleven and twelve miles; and the ridge consists of the following principal heights, beginning from the extreme north at *Great Mell Fell* (1,760):—

Little Mell Fell (1,657) lies on the *dark brown* isolated mass that is seen on the contour map between *Ullswater* and the northern part of the western ridge; it opposes, as it were, *Great Mell Fell*; to the south of this isolated mass is *Gowbarrow Fell* (1,579), and still nearer the lake *Gowbarrow Park* (1,434), where the daffodils abound that so charmed Wordsworth and inspired the poem he wrote on them.

Great Mell Fell is succeeded to the south-west by *Great Dodd* (2,807), *Watsons Dodd* (2,584), *Stybarrow Dodd* (2,756), *Raise* (2,889), *Low Man* (3,033), *Helvellyn* (3,118), *Dollywaggon Pike* (2,810), and *Seat Sandal* (2,415). The mean maximum height of this ridge equals 2,685 feet, which is in excess of that of the whole body.

It has been noticed how little the western side of this ridge had been scored by water-courses, one little mountain stream alone contributing to *Thirlmere* at its foot. If, however, we examine the eastern flanks, it will be found that they are deeply scored by the many waters that act as affluents to *Ullswater*. To the east of the *e* in the word Thirle, just below the dotted county boundary line, will be seen a rather shallow loop, which gives passage to *Glenridding Beck*, the effluent of *Kepplecove Tarn* (1,825), and *Red Tarn* (2,356), which lies just under *Helvellyn*; the beck then enters *Ullswater* to the south of the hotel.

The next valley-loop to the south is that of *Grisedale*, which receives the waters of *Grisedale Tarn* (1,768), and carries them to the *Goldrill Beck*, just before it enters the

head of the lake: the third in succession southward is the valley-loop of *Deepdale Beck*, which rises just below *Fairfield* (2,863), and finally joins the *Goldrill* in *Patterdale*. To the north of these dales, at the point where the county boundary crosses the *light blue area*, will be observed a slight indentation in the 1,000 feet contour; this is *Glencoin Dale*, through which runs a mountain stream from *Hartside*. To the north of this small stream will be found a more considerable depression giving exit to a stream, that instead of running to the north, an error that unfortunately escaped me, should bend its course towards the southern end of the isolated *dark brown* height between the main ridge and the lake, and finally empty its waters into the lake to the south-west of *Gowbarrow Park*, at what is known as *Aira* or *Airey Point*. This stream is *Airey Beck*, and noted for its cascade just above *Lyulph's Tower*, called *Airey Force;* the beck rises in *Deepdale*, between *Hart's Side* and *Great Dodd*. Wordsworth in his poem on it says, that the brook itself is "as old as the hills that feed it from afar"! Between the *Glenridding* and the *Grisedale loops* is *Birkhouse Moor* (2,318), and the highest point of the *dark brown* ridge separating the latter dale from *Deepdale Beck* is *St. Sunday Crag* (2,756). Between the western and the central ridges is seen a somewhat bifid loop pointing to the south; it gives exit to the sources of *Goldrill Beck*, the southern affluent of *Ullswater;* these are derived from the high land of *Candale Moor* (2,214), *Middle Dodd* (2,106), and *Little Hart Crag* (2,091).

The Central Ridge has a north-easterly direction, lies to the south-east of the lake and separates it from *Hawes Water*. Along its ridge the old Roman road or *High Street* was carried, portions of which still remain. This interesting highway has a course which may be described as extending from a point just below the apex on the eastern side of the *dark brown* loop representing *Troutbeck*, before mentioned, it then rises in a slightly north-eastern direction, and attains

at *High Street* an altitude of 2,633 feet; passes to the east of *Hayes Water*, and then proceeds over *Raven How* (2,356), *Red Crag* (2,328), *Weather Hill* (2,174), *Loadpot Hill* (2,291), *Swarth Fell* (1,832), *Whitstone Moor* (1,213), to the extreme point of the *Central Ridge*, where it has an altitude of 1,000 feet. So that the mean maximum height of this remarkable road along the central ridge amounts to nearly 2,000 feet above the sea-level (1,982 feet).

The principal loops along the north-western side of this ridge are, beginning from the north, the one which gives exit to the effluent of *Hayes Water Gill* (1,383), the lakelet shown in the map. This stream joins the *Gold-rill*; further north is a cluster of three or more loops through which the waters gathered on *Martindale Common* flow as affluents to the lake, near which they unite before passing into it to the west of *Hallin Fell* (1,271), a height not shown in the map, but situated to the north of the *elbow-like* bend which the lake makes just opposite the base of the cluster of loops. The chief heights which skirt the lake are *Swarth Fell*, *Loadpot Hill*, *Steel Knotts*, *Martin Fell*, the *Dod*, *Birk Fell* (1,670), and *Place Fell* (2,154); the last is opposite *Glenridding*, and commands a splendid view.

The opposite flank of this ridge, looking towards the east, is deeply looped by the tributaries to the river Lowther, the chief of which is the *Hawes Water Beck*, the effluent of the lake of that name, 694 feet above the sea level, which receives through its affluent the waters of *Blea Water* (1,584); between this tarn and *Hayes Water*, *High Street* runs. *Hawes Water* separates the central ridge from the *Eastern* which may be briefly described as the high land to the north of the main water parting, from which rise the initial sources of the river Lowther; the projecting *dark brown* masses separating the valley loops are respectively, from north-west to south-east, *Naddle Forest* (1,639), *Ralfland Forest* (1,439), and *Low Fell* already named.

The southern ridges include *Shap Fells*, and the minor ridges which extend to the south-east from them, and separate the valley-loops of the many sources of the river *Lune;* the first of which makes its exit as *Wasdale Beck* just to the south of the river Lowther. The latter, however, turns to the north, whilst the former makes a sharp turn to the south, soon after which it is joined by *Borrow Beck*, which issues from the deep loop obscured by the "shaded inland boundary" of the Lake District. The remaining features of the southern part of this mountain mass have already been described.

III. *The Skiddaw Mountain Mass*

Lies to the north like a wedge between the two masses just described, from which it is separated by the valley through which on the east the sources of the river Greta flow, before joining the Derwent; and on the west by the Derwent valley and the upper part of *Bassenthwaite.* This huge mass standing right in front of the mouths of *Borrowdale* and *St. John's Valley*, bars the northerly winds from exercising their full power in them; whilst its position and size strike one at once that it must have been the grand diverter of the glaciers that once filled them to the north-west, where *Bassenthwaite* now lies, and that the long projecting ridge of *light brown* from its western side described above as bearing *Mootan Common*, continued the diverting influence to the west, and thus brought about the change in direction of the Derwent valley from its original north-westerly trend to the south-westerly one that its river has in its course to the sea at Workington.

The *Skiddaw Mass* (III) may be roughly stated to consist of about fourteen square miles above the 1,000 feet contour enclosing its *dark brown* area. Its highest points are *High Pike* (2,157), *Great Lingy Hill* (2,000), *Carrock Fell* (2174), in the north; *Dead Crags* (2,189), *Great Calva* (2,267), and

Bowscale (2,306), in the centre; and *Skiddaw* (3,054) and *Saddleback* or *Blencathra* (2,847) to the south and west, and south and east respectively; so that the mean maximum height of its northern portion reaches 2,122 feet, of its central portion 2,254 feet, and of its southern 2,950 feet; equal to a mean maximum height for the entire mass of 2,115 feet. The contour of Skiddaw is not deeply indented by river-valleys. At its extreme north there are loops for the *Skiddaw* tributaries to the river *Caldew*, which are divided towards that river by the pear-shaped outliers of *dark brown* to the north and north-west, on which lie *Caldbeck Fells* (1,125), the highest point being to the west (1,221). The small round *dark brown mass* to the south of the pear-shaped one is *Greenhow* (1,053), which helps to divert the river *Ellen* to the north-west after emerging from the looped north-western side of the Skiddaw mass, and after receiving the waters of the lakelet *Overwater*, which is seen to lie as it were in the broad loop of the Ellen as it issues from the Skiddaw mass. In this, however, it is considerably assisted by the pear-shaped mass, and another *dark brown* isolated mass to the south-west, on which a "*Tumulus*" has been raised at a height of 1,466 feet.

Below the source of the *Ellen* an affluent of *Bassenthwaite* issues just beneath *Dead Crags.* The western and southern parts of the *Skiddaw* contour give exit to several small unnamed mountain streams whose destination is the river *Derwent*; on the extreme south, however, will be found a considerable loop, through which flows *Glenderaterra Beck*, on its way south to form the river *Greta* just below where the *Naddle Beck* falls into it. From this point round to the eastern side of the mass only small unnamed mountain streams pass the western line to join the *Glenderamackin beck*, the exit of which is indicated by the loop on the eastern side that opens in a north-easterly direction; this valley-loop is occupied by the beck just named, which takes

its rise to the north of *Saddleback* and reaches the waters soon after of *Scales Tarn.*

To the north of this loop is seen another of greater size, which bends round from its original north-easterly trend to assume a south-easterly one. This is the head of the valley of the river *Caldew*, which is seen to issue from it and then turn at right angles to the north; this now rises to the south of *Skiddaw Forest*, as *Salehow Beck*, and pursues a north-easterly course, until it reaches the valley between *Bowscale* and *Carrock Fell;* at the foot of the former, on the south it receives the waters of *Bowscale Tarn.* Midway between the *Caldew* loop and the extreme northern point, issues the *Carrock Beck* tributary of that river.

To the east of these valley-loops is seen an isolated *dark brown* mass of elevated ground; it is the site of *Greystoke Park*, and has a mean elevation between 1,100 and 1,200 feet. From the deep loop on its north-western side issues the *Gilllcambon* branch of the river *Caldew*, whilst through the loop on the south-west issues one of the sources of the river *Petterill.*

IV. *The Black Comb Mountain Mass.*

This elevated area in the south-west of our area, is like that of *Skiddaw* in the north, not only physically, but geologically distinct from either the *Scafell* (I.) or the *Helvellyn* (II.) masses. This mountain mass lies to the south-west of the extreme point of the *south-western* limb or ridge proceeding from the *Scafell Mountain Mass* (I.), and is separated from it by the valley (*Brown Rigg*) in which the *Crosby Gill* flows to the south-east and joins the river *Duddon*, whilst the *Devoke Water* (766) occupies the north-western portion, and discharges itself by the *Linbeck Gill* to the north-west into the river *Esk.*

The *Black Comb* mass has its long axis in a direction nearly north and south, and has a length above the 1,000

feet contour of between seven and eight miles. Its two highest points are *Wood End Height* (1,597) at its extreme north, and *Black Comb* (1,969) at its extreme south. *Hesk Fell* (1,566) overlooks the valley of *Crosby Gill*, which has on its left bank the *Ulpha Fell*, and *Great Worm Crag* (1,400). The mean maximum height of the whole mass amounts to 1,661 feet. On all sides its contour is indented or looped by the many mountain streams that take their origin on each side of its ridge or water-parting; on its northern end there are two slight depressions, the western giving passage to the affluent of *Devoke Water*, which rises to the north of *Wood End Height*, whilst the eastern is the opening for the sources of *Crosby Gill; Rowantree How* dividing the two valley loops. On the eastern side the upper half of the contour is indented by the mountain streams which fall into the river Duddon; whilst from the lower half, beginning at the deepest loop on this side, issue the source and tributary streams of *Black Beck*, which falls into the river *Duddon;* and still further south the independent streams, which go to form *Whicham Beck*, issue, but instead of going to the *Duddon*, are diverted by the elevated *light blue* mass to the south (*Low Scales* and *High Scales*), around which they travel as *Whicham Beck* (*Haverigg Pool*) to the estuary of the Duddon.

Black Comb is the headland so frequently seen from the Isle of Man, where, when it is like a black cock's comb,[1] as it frequently is in winter, it is reckoned a sure storm signal. The writer has frequently seen and sketched it from Douglas, whence can also be seen the *south-western* ridge of the *Scafell mass*, and the *Scafell* ridge itself, with the snow lodged in the recesses of its "rugged ribbed peaks." In summer, when the air is clear and the sun is shining upon them, the mountains of Cumberland afford a splendid sight from the eastern heights near Douglas.

[1] Mariners call it the "*Black Comb*," not Combe, as *cwm*.

V. *The Pennine Chain Mountain Mass.*

Incidentally in previous chapters, especially when describing the physical boundaries of this area, this important climatic factor has been repeatedly discussed; it will therefore require less detail now than the other four masses have demanded.

On the *Contour Map*, this mass, so far as that portion of it which lies above the 1,000 feet contour line, is represented as consisting of two distinct *dark brown* masses; one at the extreme north-eastern side of the area, occupying the whole of the inland boundary of Longtown, and about a fifth of the inland boundary of the adjoining district of *Brampton;* then comes a gap characterised by a *light brown* area of less height, occupying a portion of the remainder of the *Brampton* inland boundary, also divided into two portions by the *light blue* valley-loop of the river *Irthing*, in fact this gap of low elevation along the course of the North Pennine Chain inland boundary may be termed the *Irthing*-and-*Tyne-Gap*, as it lies between the *valley-loops* of the sources of these two rivers; the former deriving its main branches from *Grey Fell Common*, in the *dark brown mass*, in the *Longtown* District, as well as from the uncoloured area between the county boundary and the *crimson* Pennine water-parting line, where it is deeply looped towards the east; these initial streams, the sources of the river *Irthing*, then flow towards the county boundary, where they join it, as it forms the portion of that line terminating at 55° N. Lat.; at which point the river turns in a south-westerly direction, and pursues its course to the south-west, occupying from above downwards the *light* and *dark blue* loops in succession. The *Cumberland* sources, which take their rise in *Longtown*, issue from the bifid *light brown* loop in the north-east of the *Brampton* district. To the south of the *Irthing* loop, along the *crimson* line just indicated, is another deep loop pointing westward; this is occupied by

one of the sources of the *North Tyne*, the *Wark Burn*, which takes its rise to the east of *Great Watch Hill*, that lies on the *crimson* line of the *Pennine water-parting*, although it has an altitude of less than 1,000 feet. From this point to the entrance of the *crimson* line into the main mass of *dark brown*, in the southern part of *Brampton* district, the mean altitude of the gap between the two *dark brown* masses does not exceed 883 feet; the *crimson* line at the point of entrance into the dark brown should have been carried further west than it is in the map to the base of the letter A in Brampton. It will be seen that the *South Tyne* takes its rise in the *Alston* district on the high land of *Alston Common*, and that nearly the whole of this district lies to the east of the Pennine water-parting.

We now come to the main mass of the *dark brown Pennine boundary*, and find it occupying the remainder of the north-eastern border of our area, and deeply and broadly looped by the sources of the rivers which flow down the eastern *watershed* of the North of England on their way to the North Sea, and on the south-western side the 1,000 feet contour line is looped all along its course by the tributaries to the river *Eden*, which occupies the valley below it throughout its entire length. In the *Brampton* district the deepest valley-loop, having a north-western direction is occupied by the river *Gelt's* sources, the principal of which rise to the west of *Butt Hill*, lying on the *crimson line*, and from the high ground of *Croglin Fells*, and *Geltsdale Middle.* The *Gelt* enters the *Irthing* before that river forks into the *Eden*, to the south, in the *Penrith* district, is another loop having rather a south-westerly trend; this is traversed by the *Croglin Water*, which enters the *Eden* through its right bank to the south-west. The next broad and rather bifid loop to the south gives rise to the *Raven Beck*, which forks into the *Eden* at *Kirkoswald;* then still further to the south is a group of loops through which the *Eden* tributaries flow from *Melmerby* and *Ousby*, and after

uniting fall into the *Eden* near *Little Salkeld*, in conjunction with the *Briggle Beck*, the sources of which occupy the loops still further south in the *East Ward* district. Still further to the south-east is a well-defined valley-loop, in the *dark brown mass*, which corresponds with the loop in the *crimson* line above where the Pennine water-parting is seen to turn suddenly to the north, and then as suddenly bend to the south-east. The valley thus indicated contains to the south-west of the water-parting the sources of the *Hilton Beck*, which take their rise from *Hilton Fell* (2,000), and then unite to pass through the valley-loop in the 1,000 feet contour and so join the river Eden through its right bank, just above *Great Ormside* on its left. Between the outlet of this mountain stream and the important group of loops at the extreme south-east corner of the 1,000 feet contour, only one or two mountain streams cross that line from *Burton* and *Warcop Fells*. At the extreme south-east corner of the Vale of Eden is seen a large group of valley mouths, the loops of which correspond with similar loops in the *crimson* line of the Pennine water-parting. The two northern loops give passage to the *Swindale Beck* and its tributary *Angill Beck*, the former of which rises in *Musgrave Fells*, and the latter from *Iron Band* (1,750), both heights being south-west of the county boundaries, which at these points are on the outside the Pennine water-parting; from this elevated land the streams converge, and after union enter the Eden as *Swindale Beck* to the south of Great Musgrave village. In the south-east and south are two other large loops in the *dark brown mass*, which are found corresponding with two well-defined and sharp-pointed loops in the *crimson* line of the main water-parting; the more northern of which extends to the county boundary, and is coincident with it for some distance; this loop gives passage to *Argill Beck*, which rises in *Stainmore Forest*, close to the county boundary, near the Roman Fort (1,562) and road; whilst in the southern and lesser

loop the river *Belah* flows after the union of its many sources from *Kaber Fell* which is encircled by the corresponding loop in the *crimson* line. These two water-courses then unite, and as the river *Belah* enter the Eden to the south of *Swindale Beck*, at the point where the *light blue* loop is seen projecting upwards from the 500 feet contour into the *light brown* area. We next come to the sources of the river *Eden* itself, which we find occupying the long sharp-pointed loop having a direction due south, which on its course passes south to north, cuts *Mallerstang Common* in two, the eastern portion of which is overhung by *Mallerstang Edge*. From its source as *Red Gill* on *Black Fell Moss* (2,200) it takes a south-westerly direction, and then as *Hell Gill Beck* to the north of the *crimson* Pennine line and the county boundary, where these two lines coincide, it turns suddenly to the north, and then enters its valley at the extreme sharp end of the loop in the 1,000 feet contour line, to pursue its course until it enters the *light blue* area, where it receives its tributary the river *Belah* just described; in its course from its source on *Black Fell Moss* to this point its course resembles the form of a shepherd's crook. At the point where it turns to the north it is separated by the *crimson* line of the main water-parting from the source of the river *Ure* or *Yore*, which rises at *Ure Head* (2,186) on *Abbotside Common*.

Having now gone through the several points of interest connected with the physical geography of the *Pennine Mountain Mass* (V.), it remains only for me to connect this important elevated area, containing as it does the *Pennine water-parting*, with the *Helvellyn* (II.) and the *Scafell* (I.) mountain masses, within which the *Great Transverse water-parting* of the English Lake District stretches from east to west.

The Connection between the Pennine Water-parting and the Great Transverse Ridge.

When describing the *Helvellyn Mountain Mass* (II.), the great transverse ridge was said to run through it to the point where the 1,000 feet contour line encircled *Low Fell* (1,135); from which point the ridge descends into the *light brown* area to the south of the sources of the river *Lowther*, where it separates the watershed of that river, from the sources of the *Lune* on the south. The ridge then ascends to enter the most western projection of the outlying *dark brown mass* that stretches from north-west to south-east across the name of the county (Westmorland). This mass curves towards the north at its north-western end, where it lies on *Red Gill Common*, near which is a British camp; from this point it stretches between ten and eleven miles to its extreme south-east end, where it abruptly ends and overlooks the valley which has been cut by *Potts' Beck* on its way to join the river *Eden*, as *Helm Beck*, near the village of Little Ormside. At this point the great transverse ridge descends to the Potts' Beck valley, crosses it at a level of 800 feet, and then immediately ascends the small triangular *dark brown* isolated mass, which lies between the elongated mass just mentioned, and the large *dark brown* mass lying to the west of the valley of the *Eden*, which may be described as a triangular mass, having its base at the county boundary to the south, and its apex surmounted by a head-like mass bending to the north-west, and connected with the main mass by a neck of high land.

We will now trace the *transverse ridge* from *Low Fell*, the extreme point of the *Helvellyn* mass (II.).

After descending from this height to the pass of *Potts' Beck*, it ascends to *Shap Thorn* (1,129) (Hardendale Fell), the most prominent westerly projection of the long curved mass already mentioned; it then takes a south-easterly course to

Coal Pit Hill (1,315), the highest point of *Crosby Ravensworth Fell*, over *Orton Scar* (1,210), the *Knott* (1,352), *Grange Scar* (1,270) to *Armaside Wood*, where it slips to 800 feet in the *Potts' Beck Valley*, and then rises to cross the isolated triangular little *dark brown* area, on which lies *Crosby Garrett Fell*, through the highest point of which, *Nettle Hill* (1,254), it crosses to reach the north-western boundary of the valley that separates the height through which we have just followed it from the head-like mass named above, *Ash Fell*, through the highest points of which, Bassett Hill (1,233) to the neck of land connecting *Ash Fell* to *Wharton Fell*, the apex of the *triangular mass* lying to the west of the Eden valley; the transverse ridge then takes a southerly course, passing over the following heights in the western portion of *Mallerstang Common*, *Greenlaw Rigg* (1,318), *Wild Boar Fell* (2,323), *Swarth Fell* (2,235), and thence to the point where the *crimson line of the Pennine Chain* is seen to leave the county of Westmorland. It is at this point between the sources of the rivers *Eden* and *Ure*, that the *Great Transverse Ridge* unites with the *Great Pennine Chain*, and it is interesting to note that its continuity, although depressed at times, is only broken twice by water; the first time by *Potts' Beck* between the south-eastern extremities of the long isolated *dark brown* mass, characterised by *Crosby Ravensworth Fell*, and the small *triangular* mass supporting *Crosby Garrett Fell;* and the *second time* by the valley between the last height and the head-like mass of *Ash Fell*, through which the *Scandale Beck* flows in a north-easterly direction to join the river *Eden*, just after its main stream has entered the *light blue* area of its valley. Through the same valley the South Durham and Lancashire Union Railway passes.

The only *dark brown* masses that remain to be described are, (1) the elevated mass bounded on the south by the county boundary, and deeply looped on the north side by the many sources of the river *Lune;* which is seen to turn

round its westerly side and proceed south: this mass supports *Langdale Fell*, and within our area the following high points at the base of each of the four projections between the main loops, beginning from the west, are, *Uldale Head* (1,553), *Simon's Seat* (1,925), *Gartside* (2,097), and *Grere Hill* (1,750).

If we follow the river *Lune* still further south, we shall find on its left bank two detached *dark brown* masses. The more northern of the two, triangular in shape, is *Middleton Fell*, with *Calf Top* (1,999). This mass is looped on the western side by the tributaries of the river *Lune*. Still further to the south is another *dark brown* mass, like the former bounded by the county boundary; it is separated from *Middleton Fell* by a tributary of the *Lune*, *Barkin Beck*, which, after passing between *Barton Park* (1,000) and *Barton Low Fell* (1,126), falls into the main river as *Barton Beck*, below the village of Barton. It rises on *Barton High Fell* (1,794).

CHAPTER VII.

The Geology of Cumberland, Westmorland and the Lake District.

Description of the Geological Map of Cumberland, Westmorland and the Lake District—Explanation of the Index of the Colours and Signs employed—The same as used by the Geological Survey of Great Britain—Authors Referred to in this Chapter: Mr. Robert Russell, F.G.S.—Mr. J. G. Goodchild, F.G.S.—Mr. H. B. Woodward, F.G.S.—Formations Found within the Area.—Formations not Found within it—Brief History of the Formations—Sedimentary, Volcanic and Glacial—Topography of Formations—Their Relation to the Five Great Mountain Masses—To the Several Registration Districts—To the Valleys and Lakes—The Geological and Contour Maps Compared—What Horizontal Sections Teach us—Rock Structure and Scenery—Rock Structure and the Water-Partings—Sir Andrew C. Ramsay on Lake Basins—Rock Structure and Cascades—Sandstones, Claystones, and Limestones—Their Respective Functions in Connexion with Animal Life—Protection, Alimentation, and Reproduction—Their Alternative Sequence.

Description of the Geological Map of Cumberland, Westmorland and the Lake District.

The first thing to be done is to familiarize the reader with the features of the map which illustrates this part of our work; and having already described in detail the *Contour Map*, it is hoped that the contents of the last chapter will have prepared the reader to comprehend readily the geographical facts about to be discussed in the present one. In point of time the geology of the area should have preceded its physical geography, as the latter is the outcome of the former; but it is well to follow the course of the anatomist who first makes himself acquainted with the external forms

of the head, trunk and limbs of the subject he is studying before he ventures to investigate the structures lying beneath them, that are concerned in their formation and support.

The Scale. The scale of the map is twelve miles to one inch; the same as that of all the others.

Index of Colours and Signs. The colours and signs adopted are similar to those used by the Geological Survey of Great Britain. The oldest sedimentary rocks in this district are placed at the lower part of the scale, so that the order observed may be considered chronological; for instance, in Cumberland, Westmorland and the Lake District, the LOWER SILURIAN PERIOD as represented by the *Skiddaw Slates* (b_2), is the oldest within the area, although not so in Wales, Scotland, and some other parts of England, where the *Cambrian* and *Archæan* rocks have been observed. These *Skiddaw Slates* are therefore placed in the lower part of the scale although not in the lowest, for this position is occupied by the *crimson* space marked G, which includes not only *granite* but other *igneous* and *intrusive* rocks. Although granite was formerly considered as it were the basement rock of all other formations, it has been proved since then to be frequently a later deposit than the rocks amongst which it occurs. Sir Andrew Ramsay believes that the granite rocks he has seen are simply the result of the extreme of metamorphism brought about by great heat (under enormous pressure) with presence of water. In fact granite and some other igneous rocks are supposed to be the result of both heat and pressure in the presence of water on the materials of the sedimentary rocks among which they are found, and it is certain that wherever exposed, the fact is evident of enormous denudation of the strata above, which at the time of their formation contributed towards that very pressure and heat necessary for the conversion of the deposits subject to them into granite and other so-called igneous rocks. Their position, therefore, on the scale is not unnatural, although it must be

borne in mind that the sediments which have been so converted must have preceded them. Omitting the *Glacial Drift*, which is not shown on the map, the most recent formation (*Lias* g_1) is placed at the top of the scale. The colours, letters and numerals which are used to distinguish the formations, are the same as those used by the Geological Survey of Great Britain, in order that the student may all the more easily recognise them when consulting the maps and horizontal sections of that department.

In the explanation just given there is no difficulty in making it evident that the younger rocks would necessarily lie on the older, in chronological order; or that, if the several deposits had successively taken place without any disturbing influences from below, the artificial arrangement in the column of formations might have been a tolerably correct representation of what would have been found in nature under such placid conditions. The history of these geological formations, however, tells us that from time to time grand and prolonged disturbances did take place, and that during their activity the crust of the earth was constantly being upheaved in one part of the world and depressed in another; that it was subject to enormous vertical and lateral pressure, the result being widespread movements; so that what was once beneath the sea and formed its bottom, was projected above its level and became dry land; this elevation was not only gradual but persistent, until the topmost parts of the folds, into which the crust was at times thrown by enormous lateral pressure, attained in some regions altitudes amounting to thousands of feet above the sea from below which they had been uplifted; this uplifting into the atmosphere rendered the exposed islands and continents liable to the immediate attacks of the denuding influences of rain, snow, frost and ice, so that the most recent deposits of the elevated land would be washed back again into the sea by the rivers that flowed down the flanks of the land-masses; these deposits

would then be spread out over the sea-bottom in the form of gravel, sand and mud, and form other rocks, which in their turn would be upheaved and denuded in a similar manner. In the meantime the first elevated land, owing to other movements, would again retire below the sea level, and perchance to a great depth, where in its turn it would form the bed of the ocean, and as such receive again the washings from some adjacent continent that had been elevated as they once had been, and was undergoing denudation as it was once denuded; but this ancient continent, now the bottom of the ocean again, has altered in structure since its once regularly piled strata were first upheaved; now these strata are no longer regular and horizontal, nor even only curved in outline. From the time they first ceased to be the bed of the ocean, through that during which they had been thrust upwards and converted into land, they have undergone changes in structure and position, brought about by heat and pressure. What were once horizontal, have been folded, so that they have been bent into wave-like ridges, characterized by troughs (*synclines*), and crests (*anticlines*); the latter once formed the highly strained curves of the first mountain chains, but yielding more readily to the disintegrating influence of rain and frost than the compact synclines, or primeval valleys, were first brought low, until at last their strained and unsupported strata, gradually shivered by winter ice and washed down by summer torrents, were reduced to the level of the troughs, and even many thousand feet below them in some cases, until what were the first valleys stood out as mountain tops, towering above the relics of the upturned strata around them; all that might be left of what once formed the boundaries of the valleys and the flanks of the primeval mountains. On gradually subsiding below the sea-level these truncated upturned strata would then be subjected to marine denudation, which would give a last and more equable planing, but whilst doing so the position of the

strata would remain the same; so that when at last they once more became the bottom of the sea, they would receive the deposits from its waters on their planed edges, whilst the new formations would collect in horizontal layers upon them, and thus would be *unconformable* to the hardened strata below them, which at one point may be vertical, whilst in others they may lie at angles from 90° to 0°, or from being vertical to being parallel with the horizon, when the new deposits above would, although rarely, be found lying parallel or conformable with the older rocks below.

LOWER SILURIAN—SKIDDAW SLATES (b_2).

But the rocks themselves vary in their mode of origin. They are not all composed of the waste of elevated land washed down by rivers and distributed over the bed of the sea. The *Skiddaw Slates* (b_2) are described by J. Clifton Ward, F.G.S., in his admirable memoir on the geology of the northern part of the Lake District, as consisting of many alternations of mud, sand and grit deposits, now converted into slate, sandstone and grit-stone, and these metamorphosed in some parts into Chiastolite slate (or charred argillaceous sedimentary rock, with scattered chiastolite crystals), spotted schist and mica schist. No beds of *Limestone* occur in the series, and the traces of the ancient life of the period are scant. *Spotted* (or Andalusite) schist is an imperfectly foliated rock with numerous spots (undeveloped chiastolite crystals, passing into mica schist, which is a foliated rock, consisting *mainly* of mica and quartz.

There can be little doubt that the *Skiddaw Slates* had their origin in what had been washed into the sea of the period from land adjacent, which Mr. Ward considers was to the west; further, he is of opinion that they indicate comparatively shallow water, and shore conditions. The series of rocks that are next above the Skiddaw Slates and resting upon them, have a totally different origin. The clay slates, just

briefly described, were seen to be the result of the action of water on exposed land surfaces.

VOLCANIC SERIES OF BORROWDALE (F_s b_2).

The rock series next to be noticed will be found to be the result of the action of intense heat, not upon exposed land surfaces, but on the material of the earth's crust far beneath its surface and the level of the sea. Whilst the ancient land, the waste of which had been going on for untold ages, was being stripped and lessened in thickness and area, the heat below, due perhaps to the enormous pressure to which portions of the earth's crust were subject, gave such expansive power to the rocks deep down in the earth's interior, as to enable them at last to break bounds upwards, and, through the outlet made, discharge torrents of volcanic ashes and scoriæ into the air, and lava over the land; the former after a time falling to the ground to form layer after layer of volcanic dust, until a vast thickness had been acquired during ages of oft-repeated outbursts. Such is the supposed origin of the deposits known as the *Volcanic Series of Borrowdale* (F_s b_2), which Mr. J. Clifton Ward describes as rocks almost wholly made up of volcanic ash and breccia, alternating with ancient sheets of lava, and the whole traversed by dykes and masses of intrusive igneous rocks. Fossils are altogether absent.

CONISTON LIMESTONE SERIES (b_3).

Time went on; the volcanoes, which had covered the land with thousands of feet of ashes, breccia and lava, at last had exhausted themselves ; calm, such as it was, followed, during which the atmospheric agents attacked the elevated mountain mass, the materials of which had fallen through the air and been arranged in layers, more or less uniform, until the huge pile had attained an altitude of many thousands of feet. Rain and rivers, frost and ice attacked this stupendous cone or cones, as they had the old land on the west

of the Silurian sea, in which the Skiddaw Slates were formed, and the ashes, breccia and lava were hurried away to the sea below; but whilst this was doing, the land of volcanic birth began to sink bodily, until it was sheltered from further spoliation by sinking many fathoms below the level of the sea, the bed of which it became at last. Then it was that it became the resting place of the waste from the land that still remained above; which for ages continued joined to its depressed portion. At last complete submergence of the volcanic land took place. During this time the sea-bed was collecting the material of those rocks that are now known as the *Coniston Limestone Series* (b_3); which consist of, (1) dark *flaggy shales*, having *ashy beds* intercalated among them (the *Dufton Shales*, H. B. Woodward, p. 82), with bands of *nodular limestone* near their base; to which succeeded, (2) the *Coniston Limestone*, consisting of hard grey calcareous slabs and slates, containing either nodules or thin bands of dark blue crystalline limestone of variable character. Above the limestone are, (3) the *Ash Gill Shales*, consisting of grey and green calcareous mudstones, sometimes affected by cleavage, with grey crystalline limestone in the lower part. All these three divisions are included under the term "Coniston Limestone" (b_3) in the map.

With the *Coniston Limestone* series end the Lower Silurian formations of the Lake District.

In the first and second series, the *Skiddaw Slates* and *Borrowdale series*, there was no *limestone*, in the last this rock was abundant. In the first, evidence of ancient life was scant; in the second, totally absent; and in the third it was abundant. Dr. Hicks is of opinion (Woodward, p. 51), that the earlier stages of the *Lower Silurian* (Skiddaw Slates), which he includes under the *Cambrian* period, the climate was probably very cold, gradually becoming milder, until in time warm currents or seas of moderately high temperature prevailed, as indicated by the growth of *corals*. The mollusca

and the trilobites indicate marine conditions, and the sand and muddy sediments indicate the nearness of land.

With regard to the volcanic ashes of the Borrowdale series, Sir Andrew Ramsay remarks that when we consider the vast amount of these products of ancient volcanoes, there can be no doubt that, rising from the sea, some of them must have rivalled Etna in height, and as most volcanoes have a conical form, we can easily fancy the magnificent cones of those of the Lower Silurian Age.*

In the Lake District the *Coniston Limestone* series (b_3) separates the *Lower Silurian*, consisting of the Volcanic series of Borrowdale (F_s b_2), and Skiddaw Slates (b_2) from the *Upper Silurian* consisting of the following, from below upwards :—

UPPER SILURIAN (b_6–b_7).

1. *Stockdale Shales or Slates* (b_6) (in the lettering of the index, by an error, "Coniston Grits" have been placed where these should have been). These beds are considered to be the basement beds of the Upper Silurian; they form certain calcareous and gritty bands. Mr. Woodward mentions that Professor Hughes has pointed out that the graptolite mudstones, and their basement bed at Skelgill, rest on the Coniston Limestone bands, and near Coniston on the Ashgill shales. As indicated by fossils the life-forms of this basement bed do not agree with those found in the beds below them, but agree in all respects with those characteristic of the Upper Silurian period. These beds consist of pale grey and purple shales with graptolites, and containing calcareous grit of conglomerate at their base, the Stockdale shales being comparatively soft, their occurrence is generally marked by a low tract of ground.

Coniston Grits and Flags (b_6). These rest conformably upon the pale shales and graptolitic mudstones of the base-

* "Physical Geology and Geography of Great Britain," 5th ed. p. 81.

bed; they consist of hard, siliceous sandstone or grit, flags and conglomerate, with thin bands of slate. The Coniston Grits are estimated as having a thickness of 4,200 feet, and the Flags 2,000 feet (H.B.W.).

We now come to what in Wales and the West of England are known as the *Ludlow rocks* (b_7), which in the Lake District are characteristic by certain local names, such as *Bannisdale Slates* and *Kirby Moor Flags.*

The Bannisdale Slates. Mr. Aveline describes these slates as consisting of sandy mudstones divided by thin bands of hard sandstone, and occasional beds of grit. The beds sometimes exhibit false bedding and ripple marks. The sandy mudstones are much pointed and roughly cleaved, never making good slates, but often large rough slabs. The boundary line between Bannisdale Slates and Coniston Grits is very indefinite owing to the alternation of slaty and gritty beds near the junction. These are more or less the equivalents of the *Lower Ludlow.*

The Kirby Moor Flags come next in succession. These are considered the equivalents of the *Upper Ludlow* rocks. They consist of grey calcareous flagstones and grits, sometimes in thick beds, locally stained of a reddish colour, of coarse texture, and often exhibiting a massive concretionary structure. It also contains bands of coarse slate and tile-stone. The estimated thickness of these beds is 2,000 feet (H.B.W.).

Throughout the Upper Silurian period life was abundant. Mr. Aveline has proved the complete unconformity of the Coniston Limestone and overlying beds, to the volcanic series. This unconformity, Mr. Ward remarks, probably represents the time during which the *volcanic land area* was being depressed beneath the *Coniston Limestone* and Upper Silurian Sea. The latest volcanic efforts may have been made during the deposition of the Coniston Limestone, for it contains interstratified and fossiliferous ashy-looking beds and probably a lava-flow; this probable lava, west of the

Shap granite, is a true felstone and quite unlike the old lavas of the district in character.

Thus, over the whole district, during very long periods, there were deposited upon the series of volcanic strata a great thickness of *Upper Silurian* beds, amounting, Mr. Aveline estimates, in the Kendal District to at least 14,000 feet. At the close of the Upper Silurian period, there is every reason to believe that in the northern part of the present Lake District, the *Skiddaw Slates* (b_2) were buried deeply beneath the whole of the volcanic series of Borrowdale ($Fs\ b_2$) from 12,000 to 15,000 feet in thickness, *and* the *Upper Silurian* strata (b_6–b_7), perhaps 14,000 feet, making altogether some 25,000 to 30,000 feet of rock above the topmost beds of the *Skiddaw Slate.*

Mr. J. Clifton Ward thus summarizes the above facts as follows: (1) The most ancient geologic records in the district (the *Skiddaw Slates*) indicate *marine* conditions with a probable proximity of land. (2) *Submarine volcanoes* broke out during the *close* of this period, followed by an *elevation* of land, with *continued volcanic* eruptions, of which perhaps the present site of Keswick was one of the chief centres.

(3) *Depression* of the volcanic district then ensued beneath the sea, with the probable *cessation* of *volcanic activity ;* much denudation was effected; other slight volcanic outbursts accompanied the formation of the *Coniston Limestone* (b_3), and then the old deposits of *Skiddaw Slates* (b_2), and volcanic material (*Volcanic series of Borrowdale*) ($Fs\ b_2$) were buried thousands of feet deep beneath strata formed in the *Upper Silurian Sea* (*Stockdale Slates* and *Coniston Grits* (b_6), and *Ludlow* Beds) (b_7) consisting of *Bannisdale Slates* and the *Kirby Moor Flags.* We now leave the *Silurian* rocks; but before proceeding to another chapter in the geological history of this district, it will be well to make the following observations.

In the first place the term *Silurian* was applied to the

rocks first discovered by Murchison, on account of their great development in that portion of Wales which the *Silures*, a Keltic race, once occupied. The Geological Survey of Great Britain still retain the term as applied by Murchison; some recent authors, however, have adhered to Prof. Sedgwick's classification and included the Lower Silurian under the heading *Upper Cambrian;* and Mr. H. B. Woodward in his admirable work on "The Geology of England and Wales," which I have had occasion so frequently to quote, adopts this classification, but throughout this work the nomenclature and classification of the Geological Survey of Great Britain have been followed.

Secondly, as the oldest rocks in our district, not only derive their name from a people once inhabiting the part of Wales where they are well developed and first well studied, it will be well to place side by side the several formations that occupy somewhat similar horizons in Wales and the Lake District; and this I shall now do as a supplement to the list of formations attached to the "Index of Colours" given in the "Geological Map" on p. 150.

After the great and long-continued Silurian depression and accumulation, during that vast period of the formation of the Upper Silurian *above* the volcanic series, there occurred in this area a break in the succession of geological formations, so that the next series of formations, *the Devonian and Old Red Sandstone*, so well developed in Devonshire, in the South of Wales, and in Scotland, are not represented in the Lake District; or at least only imperfectly, if at all.

Mr. J. Clifton Ward has made the following remarks on this subject.

Old Red Sandstone Period. Most likely the greater part, if not the whole of this period, is unrepresented by deposits in the Lake District. The so-called *Upper Old Red* being probably but the *basement bed of the Carboniferous series.* The reason for this absence of Old Red rocks seems clear.

Geological Map.		The Lake District.	Wales and West of England.
[b_7] Ludlow Beds.	Upper Silurian.	Kirby Moor Flags. Bannisdale Slates.	Upper Ludlow. Aymestry Limestone. Lower Ludlow.
[b_6] Coniston Grits. Stockdale Slates.	Upper Silurian.	Coniston Grits and Flags.	Wenlock Limestone and Shale. Woolhope Beds. Denbighshire Grits, Flags.
		Stockdale Shales and Slates. Austwick Conglomerate. Basement Bed of Upper Silurian.	Tarannon Shales. Upper Llandovery. Lower Llandovery. Corwen Grits.
[b_3] Coniston Limestone.	Lower Silurian.	Ashgill Shales. Coniston Limestone. Dufton Shales. (Coniston Limestone Series.)	Kirnant Limestone. Caradoc and Bala Beds, with Bala Limestone. (Bala Series.)
[Fsb_2] Volcanic Series of Borrowdale.	Lower Silurian.	Borrowdale Volcanic Series.	Llandeilo Flags.
[b_2] Skiddaw Slates.	Lower Silurian.	Skiddaw Slates.	Landvirn Series. Arenig Series.

Immediately succeeding Upper Silurian times came a *period of gradual upheaval* and *unprecedented denudation*: nothing was added to the country, but huge thicknesses of strata were carried away by the denuding agents and deposited elsewhere.

It was at the commencement of this epoch of disturbance and denudation, when the *Skiddaw Slates* lay most deeply buried beneath the surface, that the effects of intense pressure and internal heat must have been greatest upon these strata. Then probably it was that the masses of *Granite* were formed —perhaps in great measure out of the *Skiddaw Slate* and volcanic series—and ate their way upwards among the superior strata, metamorphosing the neighbouring rocks, and sending dykes and quartz veins amongst those still higher, as all were contorted and cleaved by the intense lateral pressure called into play during the slow upheaval of the district. When such changes at great depth are considered, it is certainly not to be wondered at, in studying the rocks as they are now exposed to our gaze, if we find *Skiddaw Slate* changed into *Mica Schist*, and *Felspathic Ash* into *semi-crystalline Felstone*. Another point should also be remembered when we are called upon to decide between the possibility of certain beds being metamorphosed along the main line of *strike*, or such beds having been originally what they now appear. The general *strike* of this strata over the whole district being S.W. and N.E., and the *cleavage* having generally the same *strike*, it would seem that the lateral pressure producing both sets of phenomena acted in a N.W. and S.E. direction; and in all probability the greatest amount of metamorphism would be effected along the axis of the upheaval in a direction S.W. and N.E. To this long period of upheaval and disturbance Mr. Ward refers the greater number of those faults that range between N.E. and S.W., and E. and W.; whilst the N. and S., and N.W. and S.E. faults are probably of younger date, and they are usually found to shift the former.

Then there were the phenomena produced during the great unrepresented *Old Red* period; formation and partial intrusion of igneous masses; extensive metamorphism; elevation along a N.E. and S.W. axis accompanied by contortion, cleavage, foliation, and faulting of the strata: penetration among the beds of *quartz veins* and *igneous dykes;* and at the surface, an enormous amount of denudation.

Denudation. This Mr. Ward briefly considers, as it gives us an idea of the great length of time which passed between the depositions of the *Upper Silurian* and the *Lower Carboniferous.*

The Basement Conglomerate (d_1) rests sometimes upon *Skiddaw Slate,* sometimes upon the *Volcanic Series,* and sometimes (in the country to the south) upon the *Upper Silurian.* Hence, before the deposition of the conglomerate of *Mell Fell,* all the *Upper Silurian* strata had been planed away over much of the northern part of the district, and a very large portion of the beds of the *Volcanic Series,* exposing a great tract of *Skiddaw Slates.* If this denudation means a removal of some 25,000 feet or more of rock, how vast a time does it represent, how slow must have been the elevation of this block of country above the sea, to enable this great agent to effect so much, and how prodigious the sub-aërial denudation wrought upon the elevated land! Of course it is evident that the *Mell Fell conglomerate* (d_1) once extended much farther to the west, since the summit of that hill is 1,760 feet above the sea, this implying another great amount of denudation in later times.

As no fossils, save a few traces of plants, Mr. Ward observes, have been found in this deposit, its mode of origin is a little doubtful, whether accumulated in old valleys as suggested by Professor Phillips and Mr. Godwin Austen, or forming the earliest coast-line beds of the Carboniferous sea.

Sir Andrew Ramsay, in his most interesting work already

referred to (p. 112), says : "in the conglomerate (red) of the Cumbrian region scratched stones have been found, in some cases unmistakably resembling those which are allowed by all to have had their markings produced by the agency of glacier ice. A bold man might even go farther ; for opposite the mouth of the valley of Ullswater, at the outlet of the lake, there are great masses of angular boulder conglomerate, (see d_1 Geological Map), culminating in the big mound-like hills of *Mell Fell* and the neighbourhood, the stones cemented in a marly base. It is an obvious fact to skilled geologists, well known to those of the Geological Survey who mapped the ground, that some of the valleys of Cumberland are of older date than the deposition of the *Old Red Sandstone*, and standing on the ground it was impossible for him not to *feel* the idea that *Mell Fell* and *Little Mell Fell* look like, and may be, the relics of an old moraine, shed from a glacier of the *Old Red Sandstone age*, that flowed down a valley far older than that of modern *Ullswater*, and long before the special hollow in which the lake lies was formed. The mountains were much higher than now, for since then they have undergone an immense amount of denudation.

The whole subject is full of interest, and calculated to lead us further than our present object justifies, which is simply to indicate to the reader where the principal formations are to be found, and to give a brief history of their probable origin.

With regard to the origin of this *red conglomerate* (d_1), Mr. Ward remarks, that further research may better explain this somewhat difficult problem.

We now come to formations which immediately succeed this *red conglomerate.*

The Carboniferous Period.

This period is represented on the map by *Carboniferous Limestone* (d_2), *Yoredale Sandstone* (d_3), *Millstone Grit* (d_4), and the *Coal Measures* (d_5).

The Carboniferous Limestone.

This limestone is generally a tough, bluish-grey, crystalline limestone, which emits a fetid odour when punctured, probably due to sulphuretted hydrogen. The rock occurs in beds of variable thickness, but often massive, some of which are oolitic in structure. It is frequently traversed by veins of calc-spar, and by strings of nodules. Layers of chert are sometimes met with, which merge gradually into the masses of limestone. It has long been popularly termed the *Mountain Limestone*, and it was spoken of by Sedgwick as the "*Great Scar Limestone*"; it was named Carboniferous Limestone by him in 1822. (H. B. Woodward, p. 154.)

Mr. Clifton Ward states that there is no decided evidence to show that the Carboniferous strata was ever deposited over the whole of the present Lake District area; but that the *Limestone beds* once extended further towards the mountain centre than they now do is certain. The thickness of some of the *Limestones* skirting the district perhaps suggest a very considerable further extension, and the area of land during, at all events, the earlier part of the Carboniferous Period, may have been comparatively small, and have attained no great elevation.

The Carboniferous Limestone series (from 600 to 2,000 feet in thickness), forms a narrow band on the eastern side of the vale of the Eden; and bordering the western side of the vale it forms a belt around the old slaty region of the Lake District between Kirkby Stephen and Egremont. It may be seen near Ulverston, Cartmel, Kendal, Kirkby Lasdale, Sedbergh, Orton, Lowther, Caldbeck, Cleator, etc. Everywhere it forms bold hills; often presenting rough precipices towards the Lake Mountains, which are known by the name of "*Scars*," as Whitbarrow Scar, Underbarrow Scar; or "*Knots*," as Farlton Knot; or simply "Fells," like other less remarkable hills such as Kendal Fell. It rests upon the *Upper Silurian rocks* near Kendal, upon the lowest

slates near Egremont. Thus it is "unconformable" to those rocks, and the cause of this is, Phillips remarks, the great disturbance of the sea-bed which followed upon the completion of the slaty series of strata.

Generally speaking, the same author observes, this *Limestone* appears by the regularity of its beds and the purity of its calcareous composition, to have been deposited beyond the influence of the litoral agitation of the sea.

In some places (as near Ingleton in Yorkshire) its lowest beds contain abundance of fragments of the subjoined slaty rocks: near Lowther, beds, similarly placed, contain quartz pebbles; and as we proceed to the north, a series of sandstones, shales and coal, is interpolated among the limestones. This is seen chiefly on the eastern side of the vale of Eden, under the great escarpment of Cross Fell. The geologist should remark beneath the limestone range of Orton Scars a lower plateau, in which Red Sandstone prevails; for this appears to be associated with fossiliferous limestones, locally of a red colour; the whole suggesting the idea of a temporary return, during the calcareous period, of the action which had prevailed during the Old Red Sandstone era. ("Geology of Yorkshire," Vol. II. Black's Guide, p. 254.)

The deposit of this *Carboniferous Limestone* must have taken place when the area had been depressed, and the land covered by the Upper Silurian rocks formed the bed of the *Carboniferous Sea.*

Professor Sedgwick remarked in 1836, "Had our island been laid dry immediately after the Carboniferous period, without any change of relative position among the great formations, the Cumbrian mountains would have appeared as a cluster of ancient rocks, rising out of a great Carboniferous plain." (Trans. Geol. Soc., 2nd series, vol. iv., p. 47.)

The *Carboniferous Limestone* is much quarried in the neighbourhood of Hesket Newmarket. (H. B. W.)

Yoredale Sandstones (d_3).

Of the *Yoredale Rocks* and *Upper Limestone Shales*, Mr. H. B. Woodward gives the following account. They were named by Professor Phillips from their development in Yoredale (or Wensleydale) in Yorkshire, where they consist of alternations of flagstones, gritstones, shales, seams of coal, altogether from 500 to 1,500 feet in thickness.

The general characters of the *Yoredale* rocks may be thus stated. In the upper part they consist of the alternations of *limestones*, sometimes siliceous, with *sandstones*, *shales* and *coal seams*, from 80 to 450 feet in thickness. In the lower part they consist of alternations of *flagstones*, *grits*, *shales*, *coal seams*, and three or four beds of *limestone* from 250 to 1,500 feet in thickness. The *limestones* in the Yoredale rocks are remarkably persistent. Mr. J. G. Goodchild, F.G.S., gives the following list of strata in the *Alston area*. 1. *Fell Top Limestone*. 2. *Crag Limestone*. 3. *Little Limestone*. 4. *Great or* 12-*Fathom Limestone*. 5. *Four-Fathom Limestone*. 6. *Three-Yard Limestone*. 7. *Five-Yard Limestone*. 8. *Scar-Limestone*. 9. *Cockle-shell Limestone*. 10. *Post-Limestone*. 11. *Tyne-Bottom-Limestone*, 22 feet. 12. *Jew-Limestone*.

In *Edenside*, finely laminated siliceous beds are associated with the limestones of the Yoredale rocks, and they occasionally pass into beds of nearly pure chert, notwithstanding their obviously sedimentary and fossiliferous character. Mr. J. G. Goodchild, whose observations we have been quoting, is disposed to regard these beds as representing deposits of siliceous mud, derived from the *Diatoms*, *Radiolarians*, and *Sponges* inhabiting the deep sea at that period.[1]

At Hesket Newmarket there are grits, limestones, and shales, with thin bands of coal; and at Dent there are beds of black limestone or marble, known as "the Dent Limestone," which is in the same horizon as the *Hardra Limestone*.

[1] Trans. Cumb. Assoc., part vii., p. 125.

Professor Phillips remarks that the *organic remains* are extremely numerous, but generally similar to those of the *Lower Limestone.* One of the beds of this series at Alston Moor is called "Cockle-shell Lime," from the plenty of bivalve shells (*Producta*) found in it. (Op. cit., p. 256.)

Millstone Grit (d_4).

Mr. H. B. Woodward describes this rock as consisting of coarse sandstones, grits, shales and conglomerate, with occasional thin beds of *limestone* and seams of coal. It generally crops out along the margins of our coal-fields, and indeed forms the immediate foundation upon which they rest; and from the circumstance of its being *below* the coal measures, and containing, in the south-west of England and South Wales no valuable coal seams, it has in those districts been termed the "Farewell Rock." The name "Millstone Grit," was no doubt given because the formation has yielded stone serviceable for millstones.

At *Alston Moor* the Millstone Grit consists of alternations of sandstones, shales, with ironstone and coal, attaining a thickness of at least 400 feet. It is only feebly traceable parallel to the northern border of the Lake country.

Coal Measures (d_5).

The *Coal Measures* are described by Mr. Woodward as a series of clays and shales, grits, sandstones, and ironstones, characterized by abundance of *coal seams* and the general absence of *limestones*. Of these beds the seams of coal are the most persistent, while the sandstones are often very irregular and inconstant. The shales usually occur in what are termed "basins": that is in synclinal areas or troughs; these basins, however, are not necessarily the areas of deposition, but are caused by disturbances and denudation of the coal-measures, which in many tracts were no doubt formerly connected (p. 172).

Writing on the *Whitehaven, or Cumberland Coal-Field*, the same author gives the following particulars. This coal-field extends along the coast of Cumberland by *Whitehaven, Harrington, Workington*, and *Maryport*; and as the strata dip seawards, much of the coal-field is beneath the waters of the Irish Sea. Inland the coal measures extend to Aspatria. The following divisions are made in the rocks of this tract:—

Upper Series.—Purplish grey sandstones of Whitehaven, 100 to 150 feet.

Middle Series.—Developed at Cleator Moor, containing seven workable coal seams.

Lower Series.—Containing four or five thin and inferior coal seams.

The seams vary from 2 to 7 feet in thickness. It has been a matter of some dispute whether the Whitehaven sandstone should be classed as *Permian* or as *Coal Measures*. But it is now generally classed with the *Coal Measures*, although as seen in the cliff south of Whitehaven, it rests unconformably on the coal measures beneath.

At Workington the coal is obtained beneath the sea, the mines extending two or three miles under water. The coal measures in places rest on the Lower Carboniferous rocks.

A small coal field, consisting of these *Coal Measures*, and over-lying a 1,000 feet or more of Millstone Grit, was discovered by Mr. J. G. Goodchild at Argill, near Brough, in Westmorland; and this may give encouragement to those who hope to find workable coal beneath the *New Red* rocks of the vale of Eden.

The *Carboniferous Period* was one of comparative repose. True there were local oscillations of surface where the prodigious jungles grew that afforded the material for the coal seams; but these upheavals and depressions were insignificant when compared with those grander and long-continued movements which characterized the close of the Silurian Period. During this period, however, the land had begun to be de-

pressed, and the gradual and general descent of the shore and the bed of the sea favoured the accumulation of coal. But, as Phillips has remarked, all this ceased when a contrary movement of a violent character and very extensive sphere of operation took place.

The movement thus described affected with great fractures and enormous displacements the area of the coal and *mountain limestone* and more anciently solidified strata in the whole of the British Isles, and over large parts of Europe and America. Its effects in and around the Lake District may be summed up in the following abstract:—

1. The main geographical features of the district, its high mountain ridges, and broad vale depressions, received from this movement the last decided impress. The insulated character of the Lake mountains, which was evident at the close of the first great disturbance, was now modified on the eastern side by the elevation of a long and wide range of high ground extending from what is now the vale of the Tyne, to the sources of the Aire and the Ribble; and the sea which had flowed without interruption around, was bounded by the lofty isthmus of *How Gill Fell* and *Wild Boar Fell;* and rejected far to the south by a general rising on the whole of the south-eastern margin of the district.

2. The *relative elevations* of land in and around the Lake District, which we behold at this day, were acquired at that time; and their *absolute elevation* above the sea, may be stated, with much probability, at about 500 feet less than it is at present (op. cit.). Thus, as Mr. Ward observes, for succeeding ages the district, elevated high above the seas of later times, underwent that large amount of sub-aërial denudation which has resulted in the formation of our beautiful English Lake country.

The *Carboniferous Sea*, the deposits in which we have just discussed, was succeeded by the *Permian Sea*, and its more or less red deposits.

PERMIAN (e).

In England the *Permian* rocks consist of *Red Sandstones, Conglomerates, Marls,* and *Magnesian Limestone.*

Mr. H. B. Woodward states that we owe our first and best descriptions to Professor Sedgwick. The New Red rocks of the Lake District occupy the vale of Eden or Cumberland Plain, resting *unconformably* on the carboniferous rocks. They also border the sea shore from St. Bees Head to the estuary of the Duddon, and still further south at Walney Island and the adjoining portion of Lancashire. The following is a general summary of the beds :—

Keuper and Bunter. f.	Red and greenish-grey rocks, with thin beds of marls, limestone (*Stanwix marls*). 30 to 50 feet.
	Soft red and white false bedded sandstones (*Kirklinton sandstone*). 170 feet (f_c).
	Upper gypseous shales, found in Boreholes in Abbey Town, and Bowness, but now here exposed to view. 170 feet.
	Red, brown, and white fine grained sandstone, not usually false-bedded (St. Bees sandstone) (f_b). 500 to 2,000 feet.

Permian e.	Upper.	Red shales etc. 250 feet.	Lower gypseous shales: 400 to 500 feet.
		Magnesian limestone of Barrow Mouth and Hilton Beck. 10 to 25 feet.	
		Thin bedded sandstones and shales with bands of impure coal and magnesian limestones (Hilton Plant beds). 40 feet.	
	Lower.	Bright-red false-bedded sandstone (Penrith sandstone). 300 to 1,000 feet.	
		Breccia (Lower Brockram). 100 feet.	
		Breccia (Upper Brockram). 100 feet.	

The St. Bees Sandstones (f_b), is quarried at Penrith and Lazonby (Lazonby stone). The term "Brockram" (signifying broken rock) is locally applied to the breccias which are formed to a large extent of fragments of *carboniferous limestone* embedded in a red sandy matrix. They are well developed near Appleby and Kirkby Stephen, and are largely quarried in places for *lime* and building stone. Some of the beds were used by the Romans in the construction of Hadrian's Wall. (H.B.W., p. 212.) The St. Bees sandstone is quarried near Carthwaite and Aspatria. The sandstone of St. Bees Head was used in the construction of Furness Abbey. Mr. Goodchild has suggested that shore ice may have aided in its formation.

LIAS (g_1). This, the lowest member of the Oolite Period, is found in Cumberland to the west and in the neighbourhood of Carlisle, where there are about 120 feet of dark *shales* and *limestones*, in which the Rev. T. B. Brodie identified the Lima and Saurian beds. The strata are much hidden by *Drift*, but they are exposed at Quarry Gill and one or two places between Aikton and Great Orton. They were first observed by Mr. R. B. Brockbank. (H. B. W., p. 269.) Mr. T. V. Holmes, in a valuable paper on "*The Water Supply in the Carlisle Basin*,"[1] describes the patch of *Lias* south of the Eden as consisting of alternations of shale and limestone, which near Great Orton attains a thickness of 210 feet. It extends from Bellevue in the east to Aikton on the west, from Kirkampton on the north to Wiggonby on the south.

What the Horizontal Sections Teach us.

Having thus, as briefly as possible, given the characteristio features and structures of the rocks found within our area according to the most eminent practical geologists, it will be well to link some of the main facts together so as to enable

[1] Trans. Cumb. Assoc., No. viii., 1882, 1883, p. 23.

the student to remember the sequence of events in the strange history of the geological formations in the Lake District, and the counties in which it is centred. This can be done most completely by studying the horizontal sections constructed by the Geological Survey of Great Britain ; but as these are not always at hand I will endeavour to epitomize what can be learned from them. To do this I must ask the reader to follow me along the *blue curved line* crossing the "Geological Map" from N.W. through S.E., to S., and marked "*January Isotherm* 39°." This line will be seen to enter the registration district of *Wigton* from the N.W. (Solway Firth), cross the river Weaver and then proceed in a S.E. direction, through the western part of the *Penrith* district, to cross Ullswater through the district of *West Ward*, and then in a more southerly direction through the district of *Kendal*, to the west of the town and its river, to the southern boundary of the same district, after crossing the river Kent before it enters the estuary.

It fortunately happens for our purpose that, with the exception of the *Lias* (g_1) just described and the *Millstone Grit* (d_4), this line crosses every important formation found in our area. There is, however, one deposit that could not be either defined or coloured on the map without masking the other parts: this is the *Glacial Drift*, which exercises such a powerful influence on health and disease, wherever found, and which, at the very outset of our career along the "*January Isotherm*," is found to be concealing older formations such as the *St. Bees Sandstone* (f_6), so that before proceeding further it will be necessary to quote what has been so well described by Mr. T. V. Holmes in the paper referred to, and his earlier observation on "The Physical Geography of the North West of Cumberland."[1]

[1] Trans. Camb. Assoc., Part VI., 1880–1, p. 167.

Glacial Drift.

Mr. T. V. Holmes describes the surface of the ground in Cumberland bordering the Solway Firth as being most persistently covered with *Glacial Drift*, or other superficial beds, so that the amount of visible rock of *Permian*, *Triassic*, or *Liassic* age is extremely small and almost confined to the banks and beds of the rivers. Even along the rivers these lower beds may be very slightly exposed; sections in them such as those in the *Eden* at Wetheral, *Shalk Beck* above East Carthwaite, or *The Lyne* above Cliff Bridge, Kirklinton, are very seldom met with. Journeys, for example, from Carlisle to Silloth, Wigton, Wreay, Wetheral, Longtown, or Gretna, take us through cuttings from 20 to 30 feet in depth, but in none of them is anything seen, on the most careful inspection, but superficial *sand*, *gravel*, and *clay*. And although the farms and villages of this part of Cumberland are almost invariably supplied with water from shallow wells in the *Glacial Drift*, well sinkers are very careful to avoid penetrating to the lower rocks, as water attained on getting to a *clayey* stratum in the *Drift* might be lost in sinking through it and reaching a *porous sandstone* below.

The Glacial Drift is of very varied composition. It usually makes a *light* rather than a *heavy soil*, being, on the whole, much more *gravelly* than *clayey*. But at various levels seams of *clayey* material exist, which hold up much of the water falling on the surface as rain, and allow of a great number of shallow wells.

Scarcely any rain ever falls directly on the underlying rocks, the only considerable space almost, or quite free from *Drift* being a piece of country, a little more than a square mile in area, between Aspatria and West Lewton (about 3½ miles due east of the village of Allonby, and due south of the letter I, in the name of the district of *Wigton*, near the shaded boundary and within the 200 feet contour line of the one-inch Ordnance survey). But as *clayey* seams in the *Drift* are

often very thin and variable and probably often absent in certain places, much of the *rainfall* gets down to the underlying rocks sooner or later. (This is an important consideration which will be referred to when treating of the distribution of *Cancer* among females.) The greatest thickness known to be attained by the *Glacial Drift* is 190 feet 6 inches, in a boring at Kelsick Moss. At Bowness-in-Solway its thickness was 41 feet; at Lynehow, below Westlinton, 36 feet 3 inches; at Garlands Lunatic Asylum, 28 feet. In these figures a variable amount of soil is included. It will be noticed that the thickness at Kelsick Moss is quite exceptional, the average of the three other borings being quite 35 feet; and the absence of the underlying rocks in the various railway cuttings near Carlisle points to a thickness of *Glacial Drift* that may exceed an average of 35 feet, but can hardly fall short of it. And while at Kelsick Moss the beds to a depth of 92 feet are chiefly *sandy* or *gravelly*, the *Drift* thence to 198 feet 6 inches (the bottom) is mainly *clayey*. But at Garlands the 28 feet of *Drift* is made up of 26 feet of *sand* and *gravel* above, and 2 feet of *clay* beneath.

The *Glacial Drift* in the Eden valley will be described later on. We will now resume our course along the "*January Isotherm*."

What the 39° January Isotherm crosses over.

In Wigton, the line, after leaving the sea, crosses over the *Blown Sands* of the coast, and the *Raised Beach*, from which it descends to the *Alluvium* and *River Gravel* to the east; after passing which it reaches the *Glacial Drift*, on which the *Alluvium* lies, and which in its turn overlies and conceals the New Red series, coloured on the map as *St. Bees Sandstone* (f_b). This bed is seen to overlap the *Coal Measures* (d_5), that in their turn overlie the *Millstone Grit* (d_4), (which, although not actually crossed by the isotherm, is seen to the north-east of it); and the *Carboniferous Limestone* (d_2) (blue)

is seen bordering the *Volcanic Series* (Fs b_2), and at Rigg, a little to the west of the line, overlaps the *Volcanic Series* at an angle of 18° dipping N.W. *At West Fell* the site of which is where the figure 2 stands, just below the letter R, the Volcanic Series rests on the *Skiddaw Slates* (b_2), but at a considerable depth below the surface. The *Volcanic Series* lies conformably with the Skiddaw at an angle of 20°. In *Penrith,* between the figure 2 and the *crimson area* (G) occurs a fault; this marks the site of *Carrock Fell* (2,174 feet), where *igneous* rocks occur, which on the north-western side are described as *Spherulitic Felsite,* and on the south-east *Hypersthenite—Felstone Porphyry,* according to Mr. Woodward. To the S.E. of the *Carrock Fell crimson* mass of igneous rocks is another fault, so that the mass lies between the two; coincident with this fault the *Skiddaw Slate* (b_2) comes to the surface, and is found to be much contorted; we now follow it, and in doing so cross the basset-edges of the upturned black and cleaved slates (b_2), until we reach Grisedale Common, where the surface of the ground is covered with boulder-bearing *Drift Clay,* resting upon the *Skiddaw Slates* (b_2). The Horizontal Section of the Geological Survey (sheet 118) passes about 2½ miles to the west of the *isotherm,* and shows the *Carboniferous Basement Conglomerate* (d_1) resting upon the horizontal surface of the *Volcanic Series* (Fs b_2) in the form of *Great Mell Fell* (1,760 ft.), where the red conglomerate forms a heaped up mass showing unmistakable signs of extensive denudation. The *Volcanic Series* (Fs b_2) is then the superficial rock until, to the north of *Ullswater,* a fault occurs; and, coincident with it, the *Skiddaw Slates* (b_2) again come to the surface, and have been hollowed out so as to form the basin of the waters of *Ullswater*; on the south side of the lake, at *Scale How* wood, another *fault* occurs, so that the mass of upheaved *Skiddaw* Slate (b_2) seen in the map lies between the two. To the south-east of the latter fault the land rises and passes over the Dod, and other heights

between *Ullswater* and *Hawes Water*, marked *dark brown* in the "Contour Map," and coloured in the "Geological Map" as to represent the Volcanic Series (Fs b_2). These last rocks are found at the surface until the isotherm reaches the *dark blue line* indicating the *Coniston Limestone Series* (b_3) at the foot of *Garburn.* This belt lies on the Volcanic Series, at an angle between 40° and 45°, having a S.E. dip; at this point the series consists of *Coniston Limestone* (*concretionary*), *Fossiliferous Blue Shales with bands and concretions of Limestones.* To the east is seen the *crimson area* (G), indicating the position of the celebrated mass of what is known as *Shap Fell Granite*, which consists of a ground mass of quartz, felspar, and black mica, porphyritically enclosing large crystals of pinkish red orthoclose. It is of special interest from the number and wide distribution of the erratic blocks which have been derived from it. (H. B. W., p. 571.)

The author saw in 1882, at the Seamer Station, near Scarborough, a magnificent monolith of this granite, which had been found in the Glacial Drift close by. On the lawn in front of the Museum, Oxford, is another monster Shap-Fell granite boulder, which was found at Filey.

We now leave the *Lower Silurian* rocks, and at once reach the *Upper Silurian* or *Ludlow Beds* (b_7), across the upturned edges of which we pass on our way over *Bannisdale Fells*, into the three-headed dale of the Kent, where in the valley of the Mint we again meet with the red *Conglomerate Basement Beds* (d_1) dipping under the *Carboniferous Limestone* (d_2), which we see characterizing the southern part of the *Kendal* district as far as the county boundary, and continuing to the south-west at the mouths of the rivers *Leven* and *Duddon*, where it is seen dipping under the *Red Marl* (f), as it did in *Wigton*, at the commencement, under the *St. Bees Sandstone* (f_b); with this difference, that in the latter area they *dipped* more or less to the N.W., whereas in the southern the strata are more or less tilted towards the S.E.

Having endeavoured to give the reader an idea of the relation the different formations bear to each other I will now indicate briefly where they can be studied either by the medical or the geological student; for it is essential that the *facies* of the several rocks should be well observed amidst their surroundings, and the eye and hand made familiar with their structure. To the medical man the *Glacial Drift* will be of great interest, as it covers such a wide area in our district; moreover, it varies greatly at different places and within short distances: from the most permeable *sand* and *gravel* to retentive *shales* and *clays*.

The Topography of the Geological Formations.

In pursuing this part of our subject it will be more our object to give the reader certain clues to the main physical and geological features of our area, than to cumber him with an exhaustive description of them; for more minute details he must consult the Ordnance Survey and Geological Maps, on the one inch or the six inches to the mile scales, and after doing so to again study the "Geological" and "Contour" maps together. For until he has acquired a good general idea of the dependence of physical feature on geological structure, it will be impossible for him to bear in mind the complex maze of mountain and dale, which this lovely and deeply interesting district of Great Britain presents. It is proposed therefore to supplement what has already been said in the chapter on "Physical Geography," by giving a few instances of such horizontal geological sections as may be calculated to throw light upon what, at first sight, might appear too intricate ever to be understood or remembered, without having the whole series of the Ordnance Maps before us. The small maps which illustrate this work being only one-twelfth of the size of the Ordnance one on the lower scale, is only intended to convey to the mind the main features of the country under discussion; but it is hoped that by

means of the letter-press descriptions they will leave impressions, which, when once firmly fixed in the memory, will considerably aid the medical practitioner and student when their knowledge is required for practical purposes.

What the Horizontal Sections teach us.

The Great Transverse Water-Parting of the Lake District.

In a former part of this work the *Great Transverse Ridge* or *Central Water-Parting* of the Lake District was discussed, its course followed, and the principal heights given that constitute it. In returning to it now, in connection with its geological structure, we shall treat it as a *water-parting*, and therefore in relation to the sources of those waters which it separates. Strictly speaking the water-parting that divides the rivers which flow into the Irish Sea to the north of St. Bees Head from those which enter it to the south of that headland, is not quite identical with the Great Transverse Ridge; for the waters which feed *Ennerdale Water*, although they arise to the north side of the western end of the ridge, in their course to the sea to the south-west turn round its western extremity at Dent Hill, as the river Ehen, which, after receiving some considerable streams such as the river *Keckle* and *Dub Beck*, falls into the sea at Sellafield south of St. Bees Head. In fact the *north-western ridge* described in the last chapter as one of the ridges emanating from the Scafell Mountain Mass (I.), is the true continuation of the water-parting, which strikes off from the main transverse ridge at Great End (p. 60), and after pursuing a north-westerly course along the *dark brown* ridge descends into the *light brown* area where it curves to the north around the sources of the Keckle, and then suddenly changing its course to the south-west ends at *Red-ness Point* (252 ft.), just to the north of Whitehaven. In the following description of the formations that come to the surface along the line of the Great Central Transverse Ridge, we shall begin at St. Bees

Head and include the area between it and *Dent Hill* (1,130 ft.), which is the first height of importance although separated from the main mass by the lower height of *Flat Fell* (871 ft.); it is not coloured *dark brown* on the Contour Map, but its position corresponds with the letter T in WHITEHAVEN (p. 59). The next height to the east is *Blakeley Raise* (1,276 ft.), which forms the extreme western end of the finger-like ridge already described in the last chapter (p. 105).

1. *From St. Bees Head to the River Ehen* (*the effluent of Ennerdale Water*).

We in the first place find the *Red Sandstones* (f), resting on the *Permian* (e), which overlies the *Coal Measures* (d_5), underneath which is the *Millstone Grit* (d_4) not shown in the map; beneath the latter the *Carboniferous Limestone* (d_2) rises to the surface. The whole of these formations have a dip or slope seaward, and in the horizontal section which Mr. Robert Russell, F.G.S., and geologist to the Geological Survey of Great Britain, has kindly constructed for me, are seen to lie on the *Skiddaw Slates* (b_2) at the foot of *Dent Hill*; the *Carboniferous Limestone* (d_2), being the lowest, and not separated from the *Skiddaw Slates* by an intervening *Red Conglomerate Basement Bed* (d_1) as elsewhere.

2. *From the river Ehen to the eastern side of Crag Fell* (1,500 ft.).

The ridge between these two points is characterized by the *Skiddaw Slates* (b_2) in a highly contorted state, their basset edges being turned upwards towards the surface. This formation to the west has resting upon it at the foot of Dent Hill the *Carboniferous Limestone*, and to the east it overlies the *Ennerdale Syenitic Granite* (G). The heights included in this line of Skiddaw Slates are: *Longbarrow* (*Dent Hill*, 1,130 ft.), *Flat Fell* (871 ft.), *Blakeley Raise* (1,276 ft.), Grike

(1,596 ft.), and *Crag Fell* (1,500 ft.). On the north lies the great valley-loop of *Ennerdale* and *Ennerdale Water*, with the effluent *Ehen* of the latter. On the south-west is the loop of the river *Calder*. The Skiddaw Slates (b_2) are seen to be a continuation of the principal mass, which, in the north, includes the mountains of *Skiddaw* and *Blencathra*. To the south these slates are covered by the *volcanic series of Borrowdale* (Fs b_2) and by the *Eskdale Granite* (G), until they reappear in the Bootle District as *Black Combe*; on the north end of which the volcanic series (Fs b_2) is seen resting upon the *Skiddaw Slates* conformably with the granite below them at that point.

3. *Through the Ennerdale Syenitic Granite* (G).

The upper half of *Ennerdale Water* and the lower half of the valley of the *Liza* have been scooped out of the *granite mass* (G). Mr. J. C. Ward informs us that from the centre of *Ennerdale Water, Syenitic granite* forms the hill sides for full three miles up the valley; higher than this the mountains are formed of the *Volcanic Series* (Fs b_2) (*Pillar, Kirk Fell, Red Pike* and others). The granite is *red*, due for the most part to the colour of the felspar. It frequently crumbles away on the mountain tops to a *sandy deposit*, in which the irregularly shaped angular particles vary in size from that of peas to small shot. This, Mr. Ward says, may be well seen over the ground west of the summit of *Red Pike*. The principal heights along the line at this point are those beyond *Iron Crags* (2,071 ft.), *Caw Fell* (2,188 ft.), and *Haycock* (2,619 ft.).

4. *From the Ennerdale Syenitic Granite to the Shap Fell Granite* (G) *in the east.*

The reader must now be referred to the description of the course that the line of the Great Transverse Ridge or Water-parting takes between these points, to p. 60, where it will be found beginning at "Pillar (2,927 ft.)" to "Shap Fells."

The Geological Map at once shows that the structure of the heights characterizing the course of the central portion of the water-parting line consists of the Volcanic Series (Fs b_2); and a little consideration will impress the reader with the fact that the bold rugged beauty of this part of the Lake District is greatly due to the hardness of the rocks out of which it has been carved, and that it is in strong contrast with the more rounded and softened features of the mountain scenery which characterizes those areas where the more yielding *Skiddaw Slates* (b_2) are the dominant rocks; the mammated outline of *Black Combe* (Skiddaw Slates) seen from a distance backed by the iron-ribbed peaks of *Scafell* (Volcanic Series) will serve to illustrate how powerfully geological structure affects the landscape in this lovely country.

We will now follow the line between the principal valley-loops above and between which it lies in its long course over the Volcanic Series, and show how these hard rocks have been scooped out by rain, frost, and ice, to give passage to the waters that supply the lakes and the rivers.

Starting a little to the west of the last E in the word WHITEHAVEN, we have the head of Ennerdale valley-loop on the north, and that of *Wastdale* and *Wast Water* on the south, separated from each other by the line of water-parting over *Haycock* (2,619 ft.), *Pillar* (2,927 ft.), *Lookingstead* (2,058 ft.), *Kirk Fell* (2,631 ft.), and *Great Gable* (2,949 ft.). The valley-loop of *Crummock* Water and *Buttermere* lies to the north-east of *Ennerdale*, and does not approach the main water-parting, as it belongs to the *northern ridge* of the *Scafell Mountain Mass* (I.), as will be seen by the "Contour Map," which should be studied with the Geological. The next valley-loop on the north is that of *Borrowdale* and *Derwent Water;* it is bifid, the western head being separated from the eastern head of *Wastdale* by Great Gable (2,949 ft.), and *Great End* (2,984 ft.); while the eastern head of Borrowdale is separated from Eskdale by the enormous central mountain

mass of *Scafell*, which however lies to the south-west of the line; *Great End* and *Bow Fell* (2,960 ft.), with some unnamed heights between, constituting the boundary between the two dales.

At the point where the *crimson* line of the *July Isotherm* 60° crosses the water-parting, the latter alters its course to the north-east, in which direction it proceeds as far as *Dunmail Raise*, where the county boundary crosses the *light brown* isthmus between the *Scafell Mountain Mass* (I.), and that of *Helvellyn* (II.).

Just beyond this point to the south, the valley-loops of *Great and Little Langdales* are seen, in the former of which are the river *Brathay* and *Elter Water*; and to the south-east the loop of *Easedale* with *Grasmere*, *Rydal Water* and their effluent the river *Rothay*. From the point of divergence of the line in a north-easterly direction to Dunmail Raise the following heights are passed over; *Rossett Crags* (2,106 ft.), *Black Crag* (1,922 ft.), *Thunacar* (2,351 ft.), *Sergeant Man* (2,414 ft.), *Calf Crag* (1,762 ft.), *Steel Fell* (1,587 ft.), and *Dunmail Raise* (781 ft.).

Dunmail Raise, although the lowest part of the ridge, is a very significant and instructive link in the chain of the Great Transverse Water-parting, which will be shown when we come to the distribution of *Heart Disease*. It separates the valleys in which the *Wythburn* and *Thirlmere* lie to its north, and the *Rothay*, *Grasmere*, *Rydal Water* and *Windermere* to its south.

From *Dunmail Raise* the line takes for a short distance an easterly, and then for the remainder of its course a more or less south-easterly course.

On the north is seen the many headed valley-loop of *Ullswater*, and amongst its many feeders is seen high up in the *dark brown* mass the lakelet of *Hayes Water*, which is separated from the valley-loop of *Kentmere*, on the south by *High Street*, over which at a height of 2,500 ft. the Roman road was constructed, remains of which are still to be seen. To the

south-east of *Ullswater* is seen the valley-loop of *Hawes Water*, fed high up to the south-west by two little tarns, *Blea Water* (1,584 ft.), and *Small Water* (1,484 ft.). These are separated from *Hayes Water* by High Street, and from the valley-loop of Kentmere by the *Knowe, Hart Fell* (2,509 ft.); between this last height and *High Street* is the pass of *Nan-Bield* between Mardale on the north and Kentmere Fell on the south. To the south of the ridge are seen the valley-loops of *Troutbeck* on the west, and then to the south-west the three-headed valley of the *Kent*; that river occupying the most western, the *Sprint*, flowing through Long Sleddale, the central one, and the *Mint* taking its course through the most south-easterly. These have already been described (p. 99).

From *Hart Fell* the ridge continues on to *Shap Fells*, and after passing over *Adam's Seat* (2,323 ft.), *Tarn Crag* (2,176 ft.), and *Harrop Pike* (1,963 ft.), reaches *Great Yarlside* (1,937 ft.), where the *Shap Fell Granite* (G) is seen, and then on to *Wasdale Pike* (1,853 ft.), in which the volcanic series of Borrowdale (Fs b_2) reappear.

The Shap Granite and its far-borne boulders have already been referred to.

From *Small Water* a section carrying us through the Upper Silurian to Hutton Church, given by Mr. W. T. Aveline, F.G.S., in the memoir on the quarter sheet 98, N.E., new series sheet 39, will give us some idea of the structure of one of the ridges which add so much to the scenery on the left bank of the river Kent as it passes Kendal.

Section from Small Water, south-eastwards across Kentmere Pike, Dockernook Crag, Potter Fell and Benson Knot, to near Hutton Church.

On the Contour Map the above line of section is along the long *dark brown* ridge separating the valley of the Kent on

west from that of the *Sprint* (Long Sleddale) on the east; it has a south-easterly direction.

If we examine the boundary line between the *Kendal* and the *West Ward* registration districts to the east of the point, where the sources of the affluents of *Hayes Water* (on the north), and *Kentmere* (on the south) rise on opposite sides of the great transverse water-parting, which in this part of its course is coincident with the boundary between the two districts named, we shall find that the dotted line in following the water-parting, describes a triangular loop, the apex of which points to the north, and towards *High Street* (2,663 ft.), on the elevated ground of which it lies. From the north-western side of this triangle the little stream that supplies *Hayes Water* (1,383 ft.) (the tarn represented on the maps by an oblong expansion of the stream) is seen to take a north-westerly course towards the head of *Ullswater*, whilst on the north-eastern side of the triangle the affluent supplying *Hawes Water* (694 ft.) takes a north-easterly course. Now close to the source of this affluent is the little tarn called *Small Water*, lying at a height of 1,484 feet, on the *north* side of the *water-parting*, and about 600 feet below the pass of *Nan-Bield*, which leads from Mardale into Kentdale, over the transverse ridge and water-parting, which at this point is about 2,000 feet above the sea level. The tarn is not represented on the map, nor is *Blea Water* (1,584 ft.), which lies on a lower level than *Small Water* to the north, the effluent of which also supplies *Hawes Water*. To the south-west of *Small Water* is seen, on the opposite side of the water-parting, *Kentmere* (973 ft.), just below the 1,000 ft. contour, lying in the *light brown* valley-loop already described elsewhere.

On the Contour Map the line of Mr. Aveline's section may be defined as slanting to the north of the boundary dotted line between Kendal and West Ward, and then in a south-easterly direction along the *dark brown* ridge descending into

the *light brown*, and crossing the *light blue* loop (the valley of the *Sprint*), through the left limb of the capital letter T, across the valley of the *Mint*, whence it ascends the projecting *light brown* mass on which the name Kendal lies, where, to the north of the letter e, *Benson Knott* (1,035 ft.) is situated, and looks down on the town of *Kendal*, and the beautiful valley of the Kent; from this last point the line descends to the *light blue* area to the letter A, near which is the site of Hutton Church (St. John the Baptist).

On the Geological Map the same line may be traced generally through the same points, and passing over consecutively the following formations; commencing in the apricot-coloured area (Fs b_2), *the Volcanic Series of Borrowdale*), it crosses the *dark blue* strip (b_3, *the Coniston Limestone Series*), and then enters the *dark dove-coloured* area (b_6, Upper *Silurian*) to the west of the letter b; from which it proceeds south, where it crosses the valley of the *Sprint*, in which is found a loop of *reddish brown* (d_1, *Red Basement Conglomerate beds*, near which is the *blue Carboniferous Limestone* (d_2); d_1 is seen to the north of Ullswater); after crossing the valley it enters again the *dark dove-coloured* area to *Benson's Knott*, as just described, and proceeds to Hutton Church, where it ends. Having thus given the reader a general idea, by means of the maps, of the line of Mr. Aveline's section, and the various formations through which it passes, I will now add that geologist's account in more minute detail.

Small Water.

The position on the maps of this tarn has already been sufficiently indicated. Mr. J. R. Dakyns, M.A., in the same memoir in which Mr. Aveline's section appears (p. 5), remarks, that the best instances of well *bedded ash* (Fs b_2) occur in the neighbourhood of *Small Water*, whence a thick band of massive, well bedded, rough ash can be traced up to the south face of *High Street* known as *Bleathwaite Crag*. Much of the

volcanic material is *cleaved*, but it is only the comparatively scanty supply of fine-grained ash that affords workable slates.

Mr. W. T. Aveline in his section describes the *Volcanic Series of Borrowdale* (Fs b_2) at *Small Water* as composed of "*Ash and Breccia*"; at *Kentmere Pike* (2,397 ft.), as "Slaty Ash"; and further south, as the point is approached where the *Volcanic Series* is overlaid by the *Coniston Limestone Series* (b3), as "altered Ash and Breccia."

The *Coniston Limestone Series* (b_3). Proceeding from north to south, the following members of this series occur in succession: (1) lying on the volcanic series (Fs b_2), is "*Shale*," having, like the remaining beds, a S.E. slope or *dip*; on this bed rests (2) "*Felspathic Trap*," to which succeeds (3) the *Coniston Limestone*; which in its turn is covered by (4) "*Graptolitic Mudstone*," and finally (5) "*Stockdale Shales*," which last are included in the *Upper Silurian* (b_6). On the *Stockdale Shales* lie the *Coniston Flags*.

To the S. by E. of *Kentmere Pike* the line crosses *Skeggles Water* (1,017 ft.), where the *Coniston Grits* (b_6) prevail, their basset edges showing a high angle; these are succeeded still further south by the *Bannisdale Slates*, which are interrupted at *Dockernook Crag* by an outcrop of *Kirkby Moor Flags*; to the south of which the *Bannisdale Slates* again come to the surface, and remain so until *Potter's Fell* (1,090 ft.) at the extreme S.E. point of the long *dark brown* ridge in the Contour Map, where they are intruded upon by a *dyke*, to the south of which they appear on the surface until crossed by the *reddish brown* loop of the *Carboniferous Basement Beds* (d_1), in the valley of the *Sprint*, which are seen to underlie, a little to the S.W., the *Carboniferous Limestone* (d_2). At *Skelsmergh*, too, the order of super-position is, although in many places obscured by the superficial deposits of Glacial Drift, from above downwards, (1) *Carboniferous Limestone* (d_2), (2) *Red Carboniferous Basement Bed* (d_1), and *Bannisdale Slates, Upper Silurian* (b_7).

The *Kirkby Moor Flags* just seen cropping up at *Dockernook Crags*, reappear in the valley of the *Mint*, and culminate in *Benson Knott* (1,035 ft.), which height is represented in the section as the remains of a *syncline*, or primeval trough or valley, described in a former part of this chapter (p. 142), whilst the *Road* to *Sedbergh* from Kendal is seen to cross over an *anticline* about 300 ft. below the summit of the Knott. The *Kirkby Moor Flags* (b_7) continue from the last point to the end of the section at Hutton Church.[1] This is a most valuable section, and, like all the sections published by the Geological Survey, most useful to the student, who should make himself thoroughly master of their teachings. These sections to the beginner in geology are what vocabularies of familiar and household words are to the learners of a foreign language. A good stock of home strata and home terms must be acquired first; then will follow the application of the simple knowledge derived from them to our local surroundings and daily wants. A good section, on a sufficiently large scale, gives the student an opportunity of finding out for himself where his home-strata are to be found, and thus enables him to see and handle them *in situ*, and then to hammer out of them what else has to be learned. Geology has undoubtedly its grammar like the Greek or any other language, if by its grammar we understand a system of general principles and particular rules for describing the materials of the earth's crust, the historical sequence of its strata, and their relation to one another. But nobody who wishes to teach his pupil a knowledge of the materials of the earth's crust would begin with the grammar of geology, for he knows that he would soon damp the ardour of the most enthusiastic youth by such a course of study. The teacher, however, geological map and section in hand, would take his

[1] Memoirs of the Geological Survey, England and Wales (explanation of quarter sheet, 98 N.E., New Series, sheet, 39), by W. Talbot Aveline, F.G.S., J. R. Dakyns, M.A., and others. 2*s*.

pupil straight into a quarry, or by the side of some natural section in a river valley, or along the sea coast, where the sense of sight and touch would be instantly called into action, and a yearning for more knowledge of what he has seen and handled aroused. The first lesson will have then and there been taught, and have created an appetite for more, until the student at last begins to think it time to take stock of his materials at hand; he will then desire to arrange his knowledge, and begin to appreciate the value of works that treat of the principles of geology.

This chapter not being a treatise on the geology of the area, but a simple attempt to map and describe the formations characterizing its surface, in order to facilitate the study of Disease Distribution in connection with local climates, I have not introduced coloured sections; but I must advise the reader to consult the horizontal geological sections issued by the Geological Survey of Great Britain. In the descriptions of the sections and the contours, the author has rigidly adhered to the one mile to the inch scale, "new series," of the Ordnance Survey maps: and, as the maps of this work are duodecimo forms of that scale, it is hoped that there will be little difficulty in following the larger and the smaller scales together when required. The area is contained in twenty-four sheets of the Ordnance Survey maps, on a scale of one mile to the inch. In the coloured maps just described, there are many minute details omitted which, if introduced, would only have tended to obscure by crowding; for instance, the chief river valleys in the Contour Map are given, but the rivers have been sometimes omitted, and frequently when the rivers are given the names are omitted for obvious reasons. Geological and contour maps should have as few names as possible; in fact, if they were omitted altogether in small maps, and these divided into squares by fine lines, description would be facilitated and clearness preserved.

Among the horizontal sections that should be consulted is

the interesting one by Mr. J. G. Goodchild, F.G.S., published in Mr. H. B. Woodward's "Geology of England and Wales," p. 79.

It is a generalised section across the Lake district, from Silloth to Ingleton coal-field, which is just outside our bounds; nevertheless, if studied side by side with the geological map, it cannot fail to impress upon the reader not only the sequence of the strata, but the effect of upheaval and denudation. The able article on the Geology of Westmorland, in the *Encyclopædia Britannica*, was written by Mr. J. G. Goodchild, F.G.S., whose painstaking and conscientious work in this area is highly appreciated by all geologists.

There is an instructive section illustrating Professor Phillips' chapter on "The Geology of the Lakes," in "Black's Guide": it extends from Morecambe Bay to Solway Firth; from Ulverston to *Caldbeck*. In studying this section the geological map will aid the reader. In the same paper are several clear and instructive sections.

In Messrs. James Reynolds and Sons'[1] "Geological Atlas of Great Britain," there is an excellent coloured map of the geology of the Lake district, on which are noted interesting local points connected with the geology and palæontology of the area, which have been added in the last edition by Professor Robert Etheridge, F.R.S., the eminent palæontologist of the British Muséum of Natural History. I may say of this atlas that, ever since it was first published, it has always been one of my book-companions in my many journeys throughout Great Britain investigating the subject of this work, and can therefore safely recommend it as a ready and trustworthy book of reference. All the railways are marked, which is a very useful feature, as it enables the traveller to get some idea of the cuttings through which he passes.

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[1] 174, Strand, London, W.C.

The Characteristic Geological Features of the Registration Districts.

564. *Alston.*—This district lies at a great elevation above the 1,000 feet contour line, except along some portion of the course of the *South Tyne*, along the course of which the aspect is northerly.

Throughout the district the *Carboniferous Limestone* series (d_2) prevails (p. 153).

565. *Penrith.*—Within the boundaries of this district the rivers Eden and its tributary *Petterill* take a more or less north-westerly course, and give access to winds from that point; the *aspects*, however, of the sides of *Eden Vale* are on the *right* bank of the river more or less S.W., whilst those on *left* are N.E., although irregularly so; the contours, however, will assist in determining the local variations in this respect, as well as in giving the clue to the general configuration of the district.

The late Sir A. C. Ramsay,[1] in his work on the "Physical Geology and Geography of Great Britain" gives (p. 520) a section across the river *Eden*, which I will here briefly describe.

It extends from the Cumbrian mountains to the Northumbrian coal fields outside our boundary line.

To the *west* are seen the Cumbrian mountains (b_2 and F_8 b_2), on which lies, sloping towards the *east*, the *Carboniferous Limestone* (d_2); which lower down in the valley is covered by the red *Permian Conglomerates, Sandstones and Marls* (e and f). proceeding further *east*, we find the blue *Carboniferous Limestone* reappearing on the opposite (right) side of the *Eden;* this is the result of a *fault*, by which the red *Permian* strata (c e f) and the underlying *Limestone* (d_2) have been depressed, on the *western* side, and the *Limestone* (d_2) elevated on the

[1] Born 1814, died 9th December, 1891. See Obituary, *The Times*, 11th ecember, and *Nature*, 17th December, 1891

eastern, with its superincumbent *Yoredale Rocks* (d_3), *Millstone Grit* (d_4) and *Coal* measures (d_5) of Northumberland; the three last not appearing in the line of section in our area in which the *Limestone series* alone is represented in the east; although, if we turn to the *Cumbrian coal field* in the *west*, we shall find the *Millstone Grit* (d_4) represented underlying the coal measures. It will be appropriate in this place to give Sir Andrew C. Ramsay's account of the Vale of Eden.

Sir A. C. Ramsay, F.R.S., on the Vale of Eden.

Taken as a whole, from the great escarpment of Carboniferous Limestone (the inland natural boundary) that overlooks the Vale of Eden on the east, all the Carboniferous strata from thence to the German Ocean have a gentle eastern dip; so gentle, indeed, that, on Mallerstang and other high hills overlooking the Vale of Eden, outlying patches of Millstone Grit still remain to tell that once the whole of the coal measures spread across the country as far as the edge of the vale, and even far beyond pre-Permian times, for the Carboniferous Limestone on both sides of the Vale of Eden, now broken by a fault, was once continuous, and the Whitehaven coal field was then united to that of Northumberland. These gentle eastern and south-eastern dips, caused by upheaval of the strata on the west and north-west, gave the initial of all the rivers of the region to flow east and south-east.

This fact, I may note, is well seen in the eastern part of the Penrith district, and in the whole of the Alston district, which are cut off from the western mass of the area by the natural inland boundary taking its course through the former district, as described at p. 55.

Thus it happens, continues the same author, that the Tees, the Wear, the Derwent, the Tyne, the Blyth, the Coquet, and the Alne, have found their way to the German Ocean, cutting and deepening their valleys as they ran, the sides of which,

widened by time a subaerial degradation, now often rise high above the rivers in the regions west of the coal measures in a succession of terraces and limestone bands, tier above tier, as it were in Titanic steps, till on the tops of the hills we reach the Millstone Grit itself.

The author of "The Physical Geology of Great Britain" then turns to the western flowing rivers, about which, he remarks, there is far less to be said.[1]

First, *The Eden.* This river flows along the whole of that beautiful valley, through various Permian rocks for nearly forty miles. At the mouth of the valley, at and near Carlisle, a patch of New Red Marl lies on Permian Sandstones, and on the marl rests the Lias; see geological map, (g_1). Whether the whole length of the Permian strata of the Vale of Eden was once covered by these rocks it is impossible to determine, but he believed that it must have been to a great extent, and also that the Lias may have been covered by Oolitic strata.

A great fault east of the Eden has thrown these formations down on the west, so that the faulted edge of the Permian beds now abuts on the high Carboniferous hills that form the eastern side of the valley.

As these Permian and Secondary rocks were denuded away by time, the present river Eden began to establish itself, and now runs through them in a faulted hollow. What is the precise geological date of the origin of this great valley and its river course in their present form is doubtful; but it is believed that they may approximately be of the same age as the valleys just described ("The Trent, Humber, Thames," etc., p. 517); that is to say, of later date than the Oolites, and probably later than the Cretaceous, and Eocene, or even than the Miocene epoch. And so on with the other rivers of

[1] "The Physical Geology and Geography of Great Britain; a Manual of British Geology," by A. C. Ramsay, LL.D., F.R.S., etc., Director General of the Geological Survey of the United Kingdom. Fifth edition. London: E. Stanford, 1878, pp. 520.

the West of England, the Lune, the Ribble, the Mersey, and the Weaver.

The solution of Limestone by Rain-Water, containing Carbonic and other Acids, the result of Vegetable Decomposition.

Ramsay, in the work already quoted, says there can be no doubt but that the plateau of Carboniferous Limestone of the Mendip Hills, of Wales, of Derbyshire, and of the North of England, have suffered waste by solution, equal to that of the Chalk, only from the absence of flints in the strata we have no insoluble evidence by which to estimate its amount.

In Lancashire, north of Morecambe Bay, in Westmorland, and in Yorkshire, and in Yorkshire east, north-east, and north-west of Settle, the high plateaux of limestone are often for miles half bare of vegetation; the surface of the rock is rough and rugged from rain-water and the carbonic acid it contains; looking on a large scale like surfaces of salt or sugar half dissolved. The joints of the rocks have been widened by this chemical action, and it requires very wary walking with your eyes on the ground, to avoid, perhaps, a broken leg.

The Oolites must have suffered in the same way, especially when not covered by Boulder-clay; for it must be remembered, that such effects are chiefly the result of the exposure of limestones on the actual surface of the ground.[1]

566. *Brampton.*—Through the more thickly populated area of this district the valley of the river Irthing takes its course in a south-westerly direction to join the *Eden.* To the north and north-east it will be seen to be under the protection of this *dark brown* elevated area, described as part of the "Pennine Chain Mountain Mass" (p. 132), and the great Pennine water-parting, indicated by the *crimson* line.

Throughout the north-eastern portion of its area, the *Car-*

[1] Ramsay, op. cit., p. 361.

boniferous Limestone series (d_2) prevails; and along the south-westerly the red *St. Bees* and *Kirklinton Sandstones* (f_b f_c) over-lie and cover the limestones. The general aspect of the district is south-west.

567. *Longtown.*—The rivers *Line, Esk* and *Sark* have from southerly to south-westerly courses, and thus open up the district to the influence of the south-westerly sea winds. To the north and north-east lie the heights of Bewcastle, and the *crimson* line of water-parting, which have a protective influence.

It will be seen that the *Limestone series* (d_2) occupies the upper half of the district, and the *Red Sandstones* (f_b and f_c) the lower. The general aspect of the district is south-westerly.

568. *Carlisle.*—The district taken as a whole lies low, as will be seen by the contour map; and although well watered as regards rivers, their courses are not favourable to the pure air-flushing of the more powerful *south-west* sea winds, which, instead of blowing up through their valleys, blow athwart or over them. The circuitous course of the principal river the *Eden* gives access to north-westerly and northerly winds: it must be remembered, however, that the heights immediately around *Carlisle* are not great; although undoubtedly when strong south-westerly winds prevail, the remoter barriers of the *Skiddaw Mountain-Mass* (III.) must considerably break their force, and reduce their powers of air-flushing the area. The aspects of the district are northerly to north-westerly.

The geological map shows us that within this area the *Lower Lias* (g_1) covers a considerable area, and overlies the *Red Sandstones* (f_b and f_c), which surround it beyond. Again we must always bear in mind that over all lies a great thickness of *glacial drift*, which has been already described (p. 163). *Floods*, too, at times occur in this district, which, while present, interfere with the oxygenizing function of the porous *soil* on dead and decaying vegetable and animal matter, and

obstruct it for a considerable time afterwards; in fact, until the *soil* has regained its *porosity*, which it does very slowly in clayey and other retentive soils.

569. *Wigton*, to a great extent, is another low-lying district. Its rivers, the Wampool and Waver, have north-westerly courses to the Solway Firth, showing that the slope of the land they traverse is in that direction. The low foreshore, which has already been discussed in a former chapter (p. 47), enables the sea winds to exert a powerful air-flushing influence over that part of this area, which lies at the foot of the Skiddaw mountain mass to the S.E.

At the south-eastern portion of *Wigton*, where its rivers have their principal sources, we find the following rocks in succession from S.E. to N.W. The contour map will show the relation of the mountain mass just named to the remainder of the area.

The highest formations in the S.E. are the *Skiddaw Slates* (b_2), on which lie the *volcanic series* (F_s b_2); and above this last in succession, the *Limestone Series* (d_2), *Millstone Grit* (d_4), *Coal measures* (d_5), and above all the *Red Sandstones* (f_b), which last are covered by *glacial drift*, *alluvium*, *peat*, and along the line of coast by *blown sand*, which is significant of the power of the prevailing sea winds over the foreshore, and must be taken into account whenever present.

570. *Cockermouth.*—This important district has a varied configuration and geological structure. It has the third largest population of the coastal districts, over 50 per cent. of which inhabit its coastal parishes (p. 47); and thus affords evidence of the necessity of making the *sub*-district the unit of our calculations, instead of the *district;* which Dr. Farr, during my last discussion with him on the subject, told me he hoped would in future decennial reports obtain. Such a division would at least have enabled us to separate the inland populations of Cockermouth and Keswick from those inhabiting the coastal districts of Workington and Maryport.

However, varied as it is in its physical geography and geology, we must treat the district as a whole.

The local climates of the two inland sub-districts differ widely from those on the coast.

The southern part of the district lies nestled amidst the dales in which the lakes of *Thirlmere*, *Derwent Water*, *Crummock Water* and *Buttermere* repose, whose waters are collected from the great Transverse Ridge, and the radiating ridges from the *Scafell* (I.), and *Helvellyn* (II.) mountain masses; to the north of which the *Skiddaw* (III.) mountain mass blocks out the northerly currents; thus, on all four sides the southern and most inland part of this district is hemmed in: on the *west* by the great *northern ridge* from the *Scafell* mass; on the *east* by the *Helvellyn* ridge; on the *north* by *Skiddaw;* and on the *south* by the central portion of the great Transverse Ridge, the north-east ridge from the *Scafell* mass, and the water-parting crossing *Dunmail* Raise. Shut in as just described on all sides, this region of Cockermouth district affords a marked contrast to the more coastal area to the north-west, where it is traversed by the rivers *Ellen* and *Derwent*, both of which, after turning from their original northerly course, have, in obedience to the configuration of the land, swept round to the south, and thus opened up the country they water to the air-flushing influences of the south-westerly sea-winds. The aspects, therefore, of *Cockermouth*, as a whole, are as diverse as is possible almost for a district to have; nevertheless, diverse as they are, the contour map will enable the reader to discover towards what point of the compass each one looks; he must remember, however, that the southerly and south-westerly in the southern inland area will have before them the elevated Transverse Ridge to the south, and that the whole of this area is pent up under its lee as regards the southerly and south-westerly sea-winds. He need not ascend any of the great heights to convince himself of this, if he will stand on the county boundary on Dunmail

Raise, and look alternately down its northern and southern slopes.

The geological map shows us that the formations are similar to those found in the last district, except that the second in age heads the list in Borrowdale. Now if we follow the course of the river Derwent from its source near the Transverse Ridge, we shall find it flowing through the *Volcanic Series of Borrowdale* ($F_s b_2$), lying on the *Skiddaw Slates* (b_2), which are exposed just above the head of *Derwent Water*, and continue to be so until this lake and Bassenthwaite Water are passed; when the river *Derwent* crosses a belt of the Borrowdale *Volcanic Series* (F_s b_2), and then a belt of *Carboniferous Limestone* (d_2), which, during the remainder of the river's course to Workington, is seen to support the coal measures (d_5).

571. *Whitehaven.*—The greater portion of this district lies to the south of the great Transverse Ridge, which commences in it at *St. Bees Head;* to the north of which the town of Whitehaven lies. In this district it must be remembered the central water-parting terminates at *Redness Point*, just north of the above seaport. The district contains the *north-western* and *western* ridges of the *Scafell* mountain mass (I.). At St. Bees Head the coast is precipitous, and the cliffs have a sufficient height to affect the local climates to their leeward, as regards the sea-winds. Taken as a whole, the configuration of the district is such as to facilitate air-flushing by the sea-winds, especially those from the south-west. The aspects are mostly south-westerly. In the sparsely inhabited Ennerdale the valley opens to the north-west, whilst the flanks have south-westerly and northerly aspects respectively. The river *Ehen*, after rounding the *Western Ridge* of Scafell mountain mass (I.), turns to the south, and continues that course to the sea. The whole district is well air-flushed.

If we follow the courses of the river *Liza* (affluent) through *Ennerdale Water*, and then the *Ehen* (effluent), we shall cross

the following geological formations characterizing this district. The *Liza* first descends from the Transverse Ridge in the *Volcanic Series of Borrowdale* (F_s b_2), it then enters the *Ennerdale Syenitic Granite* (G), in which the upper part of the lake lies; the remaining part having its bed in the *Skiddaw Slates* (b_2), through which its effluent (*Ehen*) flows, until it is turned to the south by the elevated land of the *Carboniferous Limestone* (d_2), supporting the *Coal Measures* (d_5). The rest of the *Ehen's* course is through the *Red Sandstones* (f).

572. *Bootle.* This is a well air-flushed district, as it has the advantage not only of its triune sea inlet, into which the river *Irt* empties the contents of *Wastwater*, and the rivers *Mite* and *Esk* discharge themselves; but it shares the benefits derived from the broad sea inlet of the river *Duddon* with the next district, Ulverston. Moreover the rivers that traverse it have more or less south-westerly courses. It will be seen by the contour map, that all the principal valley-loops open towards the south-west; in fact the configuration is so pronounced that there will be no difficulty in deciding upon the aspects enjoyed by every portion of the area. In the south-west is the mountain mass of *Black Combe* (IV.), which presents a variety of aspects on account of its isolated position and comparatively great height. The *geological map* tells us that in *Black Combe*, the *Skiddaw Slates* (b_2) are represented, and that over a large area to the north-east the *Volcanic Series of Borrowdale* (F_s b_2) extend, whilst along the right bank of the *Duddon* the *Coniston Limestone* (b_3) skirts the *Volcanic series*. Again the large mass of *Eskdale Granite* (G) comes to the surface, supporting both the Skiddaw Slates and Volcanic series. The coast line presents a border of *Red Sandstones* (f).

486. *Ulverston.* This, the most southerly of the districts, is also well air-flushed; it enjoys the sea inlet of *Duddon Mouth*, and the wide estuary of the river *Leven*, which opens towards Morecambe Bay and its sea-winds. The valleys in

which *Coniston Water* and *Windermere Lake* lie, both open seaward; and although, with exception of the *South-eastern ridge* of the *Scafell Mountain mass* (I.), it has no great mountains; still scattered over its surface are many lesser heights, the axes of which are so disposed as to offer every variety of aspect and facility for the sea-winds to air-flush the valleys between them. The north-western portion of Ulverston is that occupied by the *Borrowdale Volcanic Series* (F_s b_2), skirted to the north-west of *Coniston Water* and *Windermere* by the belt of *Coniston Limestone* (b_3), whilst the southern portion of the area consists of the *Upper Silurian Rocks* (b_6 b_7), overlaid by the *Carboniferous Limestone* (d_2), supporting near the coast the *Red Sandstones* (f).

575. *Kendal.*—This district comes next in natural, although not in registration, order. So much has already been said of this district, that little more need be added. To the north it is bounded by the Transverse Ridge, and is separated from Cockermouth district by *Dunmail Raise.* To the south it has the estuary of the *Kent* opening into Morecambe Bay in a south-westerly direction. The whole of the valley of the Kent is open to the sea-wind, and this can be well seen from the *Limestone* height of Scout Scar to the south-west of Kendal town; whilst from *Orrest Head* we can see Morecambe Bay. As a fact, proving how unobstructedly the sea-winds blow up the valley of the *Kent*, I stated, two years ago in *The Lancet*,[1] that petrels had been found after storms dead in the streets of Kendal. This has been confirmed during the recent gales by several of these birds having been found in the same locality.[2] Mr. Aveline's section, described in full (p. 174), will give the reader an idea of the geological features of the northern portion of this district. The reader will find that the southern portion of it is characterized by a

[1] Vol. ii. Sept. 14th, 1889, p. 537.

[2] *Westmorland Gazette*, Oct. 10th–17th, 1891.

considerable area of *Carboniferous Limestone* (d_2), and this at points where, if floods take place, this formation has the greatest chance of neutralizing their evil effects. The aspects are mostly southerly and south-westerly.

574. *West Ward.*—This is an essentially inland district; it shares *Ullswater* with Penrith, and also has *Hawes Water*, both of which are shut out from the influence of sea-winds by the great mountain mass of *Helvellyn* (II.), and the great ridge extending from the *Tranverse Ridge*, separating *Ullswater* from *Hawes Water;* the great ridge of the Roman road. The district slopes in a northerly and north-easterly direction, and forms the *left* boundary of the *Vale of Eden*, which has already been described (p. 181). If we trace the course of the affluent of *Hayes Water*, and then follow the valley through *Ullswater*, and the river *Eamont* to the *Eden*, we shall cross all the principal geological features that characterize this district. To the south we find *Hayes Water* and the upper part of *Ullswater* lying in the *Volcanic Series of Borrowdale* (F_s b_2). Proceeding to the north-east we suddenly find the lower part of the lake crossing an upthrow of *Skiddaw Slates* (b_2), the result of two faults. Then where this formation ceases, the river *Eamont* crosses the *Red Basement Conglomerate* (d_1), which expands to the north of this lake, and forms *Mell Fell.* This *red conglomerate* then passes under and supports the belt of *Carboniferous Limestone* (d_2), which the *Eamont* crosses; and after doing so cuts through the *Permian Red Rocks* (e) and the overlying *Red Sandstones* (f c) on its way to the Eden. To the south-east are seen the *crimson* mass indicating the site of *Shap Fell Granite* (G), and extending from it in a south-westerly direction into the Kendal district, the belt of the *Coniston Limestone Series* (b_3), to the south-east of which are the *Upper Silurian Rocks* (b_6 and b_7).

573. *East Ward.*—This district contains the head of the Vale of Eden, and to the south-east is surrounded by elevated

land, as shown in the contour map by the *dark brown* areas. Moreover the south-easterly end of the great water-parting of the Transverse Ridge crosses the area to the south-east, and thus divides the water-shed of the *Eden* in the north-east from that of the *Lune* in the south-west. The general slope of the Eden valley is towards the north-west; but the boundaries of that vale have generally on the *left* bank of the river *north-easterly*, and on the *right* bank *south-westerly*, aspects.

If we take the course of the river *Eden* from its very source close to the *Pennine Chain* water-parting, indicated by the *crimson* line between the sources of the rivers *Eden* and the *Ure*, we pass first through the *Upper Silurian Rocks* (Ludlow Beds) (b_7), and then in a northerly direction through the *Carboniferous Limestone* (d_2), on which is seen lying still further to the north the *Permian beds* (e).

To the north-east of the *Permian* and *Red Sandstones* (f_6) will be seen a long line of *Skiddaw Slates* (b_2), surmounted by the *Red Conglomerate Basement Bed* (d_1), parallel to the *Red Sandstones*, and lying in the midst of the *Carboniferous* Limestone (d_2). This upthrow is the result of extensive faulting.

Localities in the above Districts where the Limestones occur.

The Coniston Limestone Series (b_3).

If we trace the belt of this calcareous series from the south-west to the Shap Fell Granite, we shall find it passing through the following civil parishes :—

Millom, in the Bootle district, Cumberland; *West Broughton*, *Torver*, *Church Coniston*, *Hawk's Head* and *Monks Coniston*, in the Ulverston district, Lancashire; *Rydal* and *Loughrigg*, *Ambleside*, *Troutbeck*, *Kentmere*, *Longsleddale*, and Fawcett Forest in the Kendal, and *Shap* in the West Ward district, Westmorland. This narrow belt of the Coniston Limestone Series lies therefore in the midst of a mean *female* population

amounting during 1871–1881 to 6,947, including about 2,300 women at and above thirty-five years of age; the time of life most liable to be attacked by cancer.

Coniston Limestone Fossils.—In the Memoirs to the quarter sheet, 98 N.E., a list of localities is given where the characteristic fossils of this period may be found: From Windermere to Shap, Skelgill, Wansfell, Trot Beck, Nanny Lane, Troutbeck, Applethwaite, Kentmere, Style End Grassing, and Long Sleddale.

The Kendal Museum contains a good collection of fossils, all of which have been identified and systematically arranged by Mr. R. B. Newton in 1885.

Mr. Jonathan Otley, whose works have already been referred to, in the sixth edition (1837) of his "Glacial Description," thus describes the course of the Coniston Limestone: it commences with a bed of dark blue transition Limestone, containing here or there a few shells and madrepores, and alternating with a slaty rock of the same colour, the different layers of each being in some places several feet, in others only a few inches, in thickness. This Limestone crosses the river Duddon near *Broughton*. Passing Broughton Mills it runs in a north-east direction through *Torver*, by the foot of the *Old Man* (Coniston) mountain, and appears near *Low Yewdall* and Yew Tor. Here it makes a considerable slip to the eastward, after which it ranges past the *Tarns* upon the hills above *Borwick Ground*, and stretching through *Skelwith*, it crosses the head of *Windermere*, near *Low Wood Inn*. Then passing above *Dove Nest* and *Skelgill*, it traverses the vales of *Troutbeck*, *Kentmere*, and *Long Sleddale*, crossing the two inter-mountains (see description of Mr. Aveline's Section) in the direction of the roads which lead over them (p. 174).

Upper Silurian Fossils—Pale Slates. These are found in the neighbourhood of *Skelgill* (Graptolitic Mudstones), *Coniston Grits and Flags. Dent*, *Winder*, *Applethwaite*, *Wansfell*, *Bannisdale Slates.* High Thorne and Crossdale Beck,

Houses; and *Kirkby Moor Flags* on Benson Knott, Underbarrow, Brigsteer, and Kitlington.

The Carboniferous Limestone Series.—The various Limestone series will probably be found in the future to be amongst the most important of all the geological formations, as regards health; whilst the *Clays* undoubtedly, from the oldest to the most recent, will have to be studied in connection with many other diseases besides cancer.

However, as the facts are at hand with regard to the last named group of malignant diseases most fatal to women at and above thirty-five years of age, they will be here given in full, and in such order as they were originally studied.

Mr. Jonathan Otley gave a very comprehensive description of the distribution of Carboniferous Limestone, or what he termed the *mountain* or *upper Transition Limestone*, which he says mantles round the mountains, in a position unconformable to the strata of the slaty and other rocks upon which it reposes. It bassets out near *Egremont*, *Lamplugh*, *Pardshaw*, *Papcastle*, *Bothel*, *Ireby*, *Caldbeck*, *Hesket*, *Berrier*, *Dacre*, *Lowther*, and *Shap*; it appears again near *Kendal*, *Witherslack*, *Cartmel*, *Dalton*, and *Millom*, from whence for some distance its place is occupied by the sea, and in the neighbourhood of *Gosforth* and *Calder Bridge*, a red sandstone intervenes, so that the limestone is either wanting or buried under the more recent formations. It dips from the mountains on every side with different degrees of inclination; the declivity being generally least on the southern side. In the neighbourhood of *Witherslack*, to S.W. of Kendal, it forms lofty isolated ridges, while the subjacent slaty rock appears in the lower ground; and it may be seen upon the surface as far as *Warton* and *Farleton Crags*, and even as far as Kellet, before it is covered by the sandstone of the coal measures.[1]

The localities whence the fossils have been derived, which

[1] Op. cit., pp. 167–168.

are found in the Kendal Museum, where they have been identified and arranged by Messrs. G. Sharman and R. B. Newton, F.G.S., are taken in geographical order from south to north. *Arnside, Grange, Blawith Point, Meathop, Sedgewick, Brigsteer, Helsington, Under Barrow Scar, Barrow-field Wood, Ash Fell, Kendal Fell, Serpentine Walks, Kettlewell, Helsfell, Halhead nab, Plumgarths, Grayrigg, Orton, Crosby Fell*, and *Shap*.

The following are the *Civil Parishes* in each registration district where the *Carboniferous Limestone* is more or less the characteristic formation, and their female populations for 1871–1881.

District.—Civil Parish.	Female Population. 1871.	1881.
Whitehaven. Total Female Population ...	23,552	... 29,192
Egremont	2,167	... 2,852
Cleator	3,218	... 4,992
Arlecdon	1,550	... 3,089
Salter and Eskat	57	... 88
Lamplugh	502	... 592
	7,494	... 11,613
Cockermouth. Total Female Population	23,616	... 28,316
Dean	398	... 413
Eaglesfield	142	... 124
Brigham	393	... 403
Papcastle	381	... 381
Bride Kirk	78	... 47
Dovenby	128	... 113
Tallentire	110	... 113
Blindcrake, Isell and Redmain ...	152	... 177
Sunderland	32	... 35
Bothel and Threapland	209	... 200
Plumbland	391	... 327
Gilcrux	302	... 253
	2,716	... 2,586

District.—Civil Parish.	Female Population. 1871.		1881.
Wigton. Total Female Population ...	11,563	...	11,959
Torpenhow and Whitrigg	152	...	134
Low Ireby	159	...	158
High Ireby	53	...	46
Bolton Low and Quarry Hill ...	273	...	299
Uldale	131	...	116
Coldbeck	768	...	613
Westward	520	...	514
Sebergham	320	...	269
	2,376	...	2,149
Penrith (West). Total Female Population	5,299	...	5,211
Castle Sowerby	422	...	389
Hesket-on-the-Forest	993	...	902
Middlesceugh and Braithwaite ...	62	...	65
Hutton-on-the-Forest	129	...	112
Hutton Roof	89	...	78
Skelton	349	...	331
Greystoke	282	...	327
Berrier and Murrah	53	...	46
Catterlin	71	...	57
Dacre	470	...	489
	2,930	...	2,796
Penrith (East). Total Female Population	6,394	...	6,506
Croglin	144	...	127
Staffield	137	...	115
Renwick	135	...	128
Kirkoswold	346	...	297
Gamblesby	134	...	118
Melmerby	138	...	148
Ousby	175	...	125
Skirwith	130	...	145
Kirkland and Blencarn	95	...	77
	1,434	...	1,280

District.—Civil Parish.	Female Population. 1871.		1881.
West Ward. Total Female Population ...	4,021	...	4,030
Yauwath and Eamont Bridge ...	156	...	140
Clifton	174	...	211
Stockbridge and Tirril	117	...	117
High Barton	181	...	190
Low Winder	9	...	8
Askham	252	...	258
Lowther	222	...	238
Great Strickland	141	...	136
Thrimby	29	...	22
Little Strickland	51	...	48
Bolton	191	...	188
King's Meaburn	92	...	90
	1,615	...	1,646
East Ward. Total Female Population ...	7,724	...	7,239
Orton	800	...	925
Appleby St. Lawrence	812	...	740
Ormside	207	...	103
Ashby	251	...	261
Little Musgrave	27	...	35
Soulby	178	...	149
Crosby Garrett	179	...	110
Smardale	54	...	23
Wailby	28	...	30
Kirkby Stephen	901	...	852
Wharton	39	...	28
Mallerstang	195	...	118
Nateby	92	...	83
Hartley	85	...	71
Winton	117	...	129
Kaber	101	...	103
Stainmoor	268	...	240
Warcop	376	...	355
St. Michael Appleby	694	...	727
Dufton	226	...	198
Long Marton	417	...	358
Milbourne and Milbourne Grange ...	143	...	125
	6,190	...	5,863

District.—Civil Parish.	Female Population. 1871.	1881.
Kendal. Total Female Population	20,333	21,460
Gray Rigg	120	102
Skelsmergh	164	170
Docker	35	29
Kendal	6,250	6,158
Strickland Kettle	306	313
Under Barrow and Bradley Field	238	235
Natland	115	136
Helsington	174	183
Stainton	190	195
Sedgwick	117	113
Levens	457	449
Crosthwaite and Lyth	345	364
Witherslack	224	265
Meathop and Ulpha	58	60
Beetham	380	526
Heversham with Milnthorpe	750	771
Preston Richard	249	288
Farleton	30	37
Holme	370	401
Hutton Roof	135	139
Burton-in-Kendal	360	343
Kirkby Lonsdale	865	892
Casterton	372	436
Barbon	137	138
	12,441	12,643
Ulverston. Total Female Population	17,771	21,452
Dalton-in-Furness	4,006	6,214
Urswick	571	617
Ulverston	3,980	5,060
Pennington	527	826
Aldingham	499	582
Upper Holker	426	434
Cartmel	139	124
Lower Allithwaite	586	535
Lower Holker	551	544
Upper Allithwaite	381	352
	11,666	15,288

District.—Civil Parish.	Female Population. 1871.	1881.
Longtown. Total Female Population	4,094	3,795
Bewcastle	501	421
Nichol Forest	316	299
Trough	61	59
Bell Bank	59	45
Stapleton	209	190
Solport	117	103
	1,263	1,117
Brampton. Total Female Population	5,299	5,211
Kingwater	181	162
Askerton	147	146
Waterhead	180	160
Burtholme	174	154
Upper Denton	55	77
Nether Denton	143	156
Farlam	641	733
Midge Holme	52	59
Castle Carrock	143	151
Geltsdale Forest	6	3
Cumrew	62	49
	1,784	1,850
Alston. Total Female Population	2,841	2,368
Alston	2,841	2,368
	2,841	2,368

The above list and its figures give us some idea of the percentage of the *female* populations, more or less subject to the influence of the Carboniferous Limestone sub-soil rock within our area; for if we take the mean population of all the above districts for 1871–1881 as amounting to 139,623 females, and the mean female populations of all the civil parishes comprised within them for the same period as equal to 57,974, the percentage of persons living in such parishes,

compared to the rest who do not, would be above 40 per cent. (41·5).

This subject will be discussed in relation to disease distribution in a later chapter. The male and female populations of the districts at different age-periods will be found in the Appendix.

Glacial Deposits.—Before concluding this chapter, it will be necessary to consider those important deposits which were brought from far and near during the Great Ice Age, and left within our area, covering much of the older formations, the features of which in the valley-lands they have masked, and in some instances interfered with the properties of the overlaid rocks.

The older members of these deposits are principally dense clay (Boulder Clay or Till) filled, in general, with boulders of all forms, some being flattened and striated, whilst others are more or less rounded; for a description, however, of the contents of the boulder clays and their origins, I must refer the reader to Professor James Geikie's work on "The Great Ice Age."

These clays overlie and mask the limestones of this area, and to some extent must interfere with the functions of these rocks. Dr. W. Fream[1] in his interesting and useful work on "Soils and their Properties," refers, however, to the fact that although the Old Red Sandstone in the Carse of Gowrie is masked by a great thickness of Boulder Clay or Till, its power is not destroyed, as witnessed by the partiality orchard fruit has for the soil above it, just as it has in Herefordshire, Gloucestershire, and Devonshire; the difference in the covering being, that in Scotland the clay had been imported during the ice age, whereas the soil covering the red-rocks in the English counties are more the result of

[1] "Soils and their Properties," by W. Fream, B.Sc., LL.D. George Bell & Sons, London, 1890. P. 106.

local origin. These glacial deposits, however, in the Lake District and other parts of Cumberland and Westmorland are not all stiff clays, which we shall see in the sequel. It would be beyond the scope of this work to follow these deposits throughout the area; it would, however, be of great service to science if their thickness and character could be ascertained and mapped for each district, beginning with the land lying on each side of water-courses, and wherever forming the sites of towns, villages, and other inhabited parts.

Professor James Geikie[1] informs us that the oldest deposit which has yet been recognised in this part of England, is a more or less tough, strong clay that answers precisely to the typical unfossiliferous Till of the Scottish Lowlands. It is quite unstratified, save here and there where the included stones show a rude kind of arrangement, similar to that which the professor has described as occasionally visible in the Till of Scotland. Like the latter it also contains in places thin irregular seams and amorphous patches of earthy sand and gravel, while its colour varies according to the district in which it is found. Thus it may be yellowish brown, grey, dark blue, or red, the colour evidently depending upon that of the rocks from the degradation of which it has been derived. So far as yet known it would appear to be unfossiliferous. The stones are angular, blunted, striated, smoothed, and polished, the more compact and finest grained rocks receiving the best dressing. Moreover they are scratched most markedly in the line of their longest diameter, irregular-shaped stones not being striated in any one direction more than another. In these and other items this *Till* tallies precisely with that of Scotland.

It rests usually upon a smoothed and striated pavement of rock, but sometimes the strata are bent over, crushed and

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[1] "The Great Ice Age and its relation to the Antiquity of Man." 2nd edition. Stanford, London, 1877.

broken underneath, and their fragments commingled with the *Till.*

Mr. J. C. Ward describes the *Till* of the northern part of the Lake District as a stiff clay, stuck full of smooth and scratched stones and boulders, and unstratified. It occurs every here and there in small patches among the mountains, in rock-sheltered spots, and may frequently be seen in the valleys, either by itself or underlying more gravelly deposits. This latter he describes as consisting of soft angular gravel (very rarely containing beds of sand) in a clayey matrix, or in large boulders in and upon it. It sometimes passes down with the Till, and either forms sloping plateaux running up the valleys (as the Till alone sometimes does) or wide-spreads of a more or less moundy appearance.

Professor Geikie states that an examination of the rock-striations proves conclusively that from all the valleys of Wales and the Lake District, there formerly issued great streams of ice, which coalesced to form one gigantic confluent glacier.

The reader should have the contour map before him whilst studying the course of the glaciers as described by Professor Geikie and others.

Mr. Tiddeman[1] has shown that the general trend of the ice-sheet in North Lancashire and adjacent part of Yorkshire and Westmorland was towards the south or south-south-east, across deep valleys and over hills of considerable elevation. This is well seen in the course of the valleys in the Bootle, Ulverston, and Kendal Districts, the valleys commencing on the south side of the great Transverse Ridge, and trending, as above described, towards the south; and he justly infers from this fact that some barrier existed in the Irish Sea which prevented it following the natural slope of the ground towards the south-west. This barrier was the ice deriving

[1] *Quart. Journ. Geol. Soc.*, vol. xxviii., p. 471.

from the Lake Mountains, (the *glaciers* that issued from the valley of the Eden, and the other valleys on the north of the Great Transverse Ridge). But if so, then some other barrier must have pounded back the latter also, for had not such a barrier existed, the glaciers of Westmorland and Cumberland would have found for themselves a more direct route to the sea than they appear to have done. The cause of this deflection was undoubtedly the presence of the massive ice-sheet that streamed from the south of Scotland, and had sufficient power to deflect the ice creeping out from Ireland. Such being the case, it is not surprising to learn that the Isle of Man and Anglesea afford evidence to show that the united glaciers or ice-sheet actually overflowed both these islands.

Mr. J. G. Goodchild has shown that the Scotch ice ascended the valley of the Eden in Cumberland, its path being marked not only by the presence of glaciated rock-faces, but also by boulders in the drift which have been transported from the high grounds in the South of Scotland. These he has traced up to the top of Stainmoor, across which the Scotch and Lake District glaciers must have followed in a general easterly or south-easterly direction. Mr. Goodchild also mentions the fact that great quantities of Scotch drift have gone over the watershed between the Eden and the south Tyne, eastward to the North Sea. This point is seen on the contour map where the *dark brown Pennine mountain mass* is disconnected, and the water-parting represented by the *crimson* line outside the boundary of the area.

The Cheviot Hills, Professor Geikie says, were smothered in ice, for he found Till with striated stones here and there on the very watershed.

Professor Geikie states on the authority of Mr. De Rance that in the north-western districts of England there are three stony clays, the lowest one of which appears to be destitute of organic remains, while the two overlying masses contain here and there a few shells which are chiefly broken

and fragmentary. He also adds that his colleagues Messrs. Tiddeman, Ward, and Goodchild, have brought forward indisputable evidence to show that an ice-sheet radiated outwards from the mountains of the Lake District, and became confluent with a similar mass of glacier-ice that crept outwards from Scotland, and greatly modified the course followed by the ice that had its origin in England. Professor Geikie expresses his opinion that before this great ice-sheet overflowed the British Islands our country stood at a higher level, and it is quite possible that in those pre-glacial times the Irish Sea may have had no existence. If this were so it would account for the fact that the oldest Till is quite destitute of marine remains, even when it occurs in close proximity to the sea, as at Little Orme's Head.

Mr. De Rance gives the following series of glacial deposits in the north-west of England from above downwards:—

4. Upper Boulder Clay.
3. Middle Sand and Gravel.
2. Lower Boulder Clay resting on a denuded surface of
1. Unfossiliferous Till or Boulder Clay.

Professor James Geikie remarks (p. 340) that the stony clays and middle sands of this region of England seem therefore to afford evidence of the following changes:—

(1) A period of excessive glaciation, when an ice-sheet covered all Wales and northern England. Before this ice-sheet appeared the land may have stood higher relatively to the sea than at present. (2) A great recession of the ice, accompanied with or followed by the submergence of the area and covered by the Irish Sea. (3) A new advance of the ice-sheet which flowed over the bottom of the sea, and mingled marine deposits and their organic contents with its bottom moraine. (4) A disappearance of intense arctic conditions, accompanied or followed by denudation of the old bottom moraines—for aught we can tell, a wide land surface may have existed at this period. (5) A gradual depression of the land to the

depth of 1,300 feet or thereabouts, during comparatively mild conditions of climate. (6) A reappearance of arctic conditions, and the last incursion of this great ice-sheet.

Fluviatile Gravel.—The same author states that considerable accumulations of *fluviatile gravel* occur in the valleys of the Lake District and Wales, often at great heights *above* the present rivers. This gravel when traced up-stream becomes coarser and earthier, and not a few of the stones even show faint traces of *striæ*. As we follow it still further into the mountains, it appears to pass into, or at least it cannot be distinguished from, morainic débris. Opposite the mouths of some of the mountain-valleys great deposits of hummocky angular and sub-angular gravel and hillocks of sand make their appearance,—elongated ridges of gravel and sand, like the more marked Kames of Scotland, are either absent or of uncommon occurrence. Professor Geikie also refers to the immense quantities of morainic matter, and the numerous *blocs perchés* which are found in almost every valley in the Lake District and in Wales. This angular earthy débris hangs on all the hill slopes and gathers on all the bottoms of the valleys. Towards the upper reaches it often takes the form of low mounds and ridges. But the terminal moraines of the great glaciers that ground out the rock basins of such lakes as Coniston, Ullswater, and Llanberis, and which may at one time have cumbered the valleys just below the lakes, have disappeared.

Mr. J. Clifton Ward[1] gives a full description of the *Moraines, Old* and recent *Lakes* in Borrowdale, Thirlmere Valley, Keswick Vale, Buttermere and Lorton Valley, Ennerdale Valley, and head of Ullswater Valley.

The Drift Deposits.—Of these Mr. Ward says there are three kinds or classes of deposit connected with the glacial period in this district; viz. (1) Till; (2) Drift Gravel; (3) Stratified Sand and Gravel.

[1] "Memoir on the Geology of the Northern Lakes," p. 86, et seq.

Mr. A. Strahan in the Memoir on the quarter sheet 98 N.E. (New Series, sheet 39), gives full descriptions of the glacial deposits to the south of the great Transverse Ridge, and introduces his descriptions with the following general remarks. On the edition of this map for superficial geology the following subdivisions of the glacial deposits are indicated by colour, the solid geology being only shown when there is no drift. The *Boulder Clay* or *Till* occupies by far the larger area; but in some of the broader valleys, as in that of the Kent, near Kendal, and that of the Lune, near Sedbergh, passes into a *gravelly deposit*, to which the name Boulder Clay is *inapplicable*, though, on the other hand, its stratification is generally far more rudimentary than that of the sands of the lowlands. The division between the two forms of drift is therefore very ill defined, nor is it possible to state definitely which is the older. The evidence points rather to their being in part contemporaneous. The drift of the whole region has a tendency to form hills, which are clearly the original heaps into which the material was piled at the time of its distribution, and not, like the hills of solid rock, remnants of an elevated mass which have been spared by denudation. The hills composed of Boulder Clay are referred to as *drumlins*, those of *sand* and *gravel* as *eskers* in the memoir from which I am quoting.

The former are extremely abundant throughout this area, and are the cause of the existence of most of the small *tarns*. The *eskers* are no less marked in the smaller areas occupied by the sand and gravel. The *drumlins* usually have their longer axes parallel to the direction of the valley in which they occur, but sometimes cross valleys obliquely, with a tendency to trend southwards. When they are found on a high tableland, as between Sedbergh and Kendal, their axes run nearly north and south, that is in the direction in which the general ice-flow was moving. The Castle Hill at Kendal and the similar hill half a mile south-east of it, are excellent

examples of these drift hills. The greater part of the drift about Kendal is of a gravelly character. A pebbly gravel rises through the alluvium as small islands, and the same deposit is seen south of Kendal, in a great number of small hummocks, or rudimentary eskers. The gravel on the west side of the river is very rudely stratified, but on the east side, half a mile south of Loundes, is a pit in an *esker*, showing well stratified pebbly gravel and grit. It may be noticed, Mr. A. Strahan adds, that the bedding has been disturbed in this pit, as is so often the case in gravels of glacial age, in such a way as to produce the appearance of a small fault with a throw of about one foot. Such disturbances may have been due to the stranding of floating ice or the melting out of a buried mass of ice.

The largest spreads of drift in the geological survey map are found in the Kent Valley, in the depression between this valley and that of the Lune by Grayrigg, in the Lune Valley above Tebay where entered by the Clough, and on the Lambriggs and Firbank Fells.

On the *contour map* Grayrigg is seen extending as a *dark brown* mass in a south-easterly direction from the M in the name of the county in the shaded inland boundary line, down which the valley of the Lune may be traced to the *dark blue* valley-loop.

The long ridge of land, Grayrigg, is seen to separate the Lune Valley, from the trident-like valley of the Kent.

In addition to these larger spreads are found long tongues of *clay drift* running up every dale, in most cases quite up to the dale head, the limit depending not so much on the height above the sea as on the form of the ground. As a contrast with the broad drift-covered tracts mentioned above, the ground between Kendal and Windermere Lake is nearly all bare, the Boulder Clay occurring only as isolated drumlins, which make a small show on the geological survey map, though their peculiar rounded outline is sufficiently

striking on the ground. Mr. Strahan thus takes the rivers in succession, giving the heights at which the several drifts have been found, and the position and direction of the striæ.

In addition to the interesting facts collected by Mr. Strahan and his colleagues, the medical practitioner would like to know the exact relations existing between the several kinds of glacial drift and the *Limestone* rocks covered by them: in fact what is required is the depth and extent of the permeable drift, such as gravels and sands, as well as that of the hard impermeable clays or clays mixed with sand or gravel.

These facts should be well ascertained wherever *floods* are liable to occur after heavy rains or thaws. Then again the area of floods both historic and recent should be noted, and their high-water marks defined on maps. It must be remembered that the effects of floods are not confined to the areas where they take place; for it is well known that the air contamination spreads in all directions; so that a town situated on an elevated part of a plain traversed by a river that seasonally flooded the adjacent land, would suffer from the effects of those inundations, even though the high-water mark of the floods may only skirt the base of its site.

The Ice Age and the Physical Configuration of the Area illustrated by the Contour Map.

Mr. J. G. Goodchild in his interesting and instructive paper on "The Ice Work in Edenside and some of the adjoining parts of North-Western England," has given the results of his work, which has extended over many years, as to the courses of the local glaciers, and how they were influenced by the ice-masses that were formed in Scotland and issued from its valleys into the Irish Sea by the Firths of Clyde and Solway.

I. Let us suppose that, at an early period of the Ice Age, when the cold was setting in, and when it was much severer than it had been in the previous period, the Pliocene, although not so intense as it afterwards became, the areas coloured *light* and *dark blue* in the contour map were filled with *glaciers;* viz. the vale of Eden, and the dale of Thirlmere, Borrowdale, that of Buttermere, and lastly Ennerdale. All these glaciers would commence on the northern side of the great Transverse Ridge or water-parting extending in a more or less southerly direction from Dent Hill in the west to that point where the North Pennine chain water-parting is seen to separate the sources of the rivers *Eden* and *Ure*, as indicated by the *crimson line.* From this elevated ridge the glaciers would move downwards in the lines of least resistance, and these would be in the Eden Valley to the N.W., in the Thirlmere and Borrowdale Valleys to the N., whilst in the remaining two it would be N.W., and W. by N., respectively. At that period the area of least resistance would be, as it is now for the waters of the rivers that water these northern valleys, the site of the bed of the *Irish Sea* and the *Solway Firth.* Towards these points therefore the early glaciers would bend their courses, and from persevering in their north-westerly and northerly trends they would be deflected to the W. and then to the S.W. as the rivers are now.

II. As time went on, and the cold increased, the glaciers in the south of Scotland, which perhaps had had the start of those in Cumberland, would have made headway in a southerly direction to the common point of least resistance, the Irish Sea, down through the Firth of Clyde into the North Channel, when they would be diverted by the north-east of Ireland in a south-easterly and easterly direction round the Mull of Galloway towards Cumberland, and *en route* would be joined by minor glaciers from the heights of Wigtown, Kircudbright, and Dumfries, and thus convert the area of least

resistance, the Irish Sea and Solway Firth, into one of the greatest, as far as the Cumbrian glaciers were concerned. Thus blockaded by the Scotch ice on the west and north-west, they had to turn back and join forces with their antagonists in making their way towards another point of least resistance, and then impelled along by the superior force of their ally from necessity, they traversed the *dark* and *light blue* areas in succession of Cockermouth, Wigton, Carlisle, Longtown, and Brampton until they reached the *light brown* area to the south of Bewcastle Fells, and at last reached the North Pennine chain water-parting where the *crimson* line is seen separating our area from that of the South Tyne in Northumberland, down the dale of which the combined glaciers of Cumberland and Scotland travelled together, carrying with them granites from the Mull of Galloway and Shap Fell to the coast of Scarborough and Filey and other parts of Yorkshire.

III. Time still went on, and at last the acme of the Ice Age had arrived; the northern glacier-hordes from Scotland had found their way across the border by another route, they had smothered the Cheviot Hills, and were at length face to face with the still growing and descending glaciers of Edenside; still searching for the point of least resistance, and finding it with their western Scotch allies across the water-parting of Bewcastle Fells; but a mightier ice-cap was now at hand ready to point out the shortest cut to the heart of England; and this was along the North Pennine chain and the vale of Eden; the Eden glaciers returning with their freight of Shap-granite, mixed up with boulders of Ennerdale, Criffel and Mull of Galloway granites, back to the S.E., where the *crimson* line over Stainmoor was crossed, and the mighty masses began to descend into the dales of Yorkshire and ceased not to proceed in their resistless course until the vale of York was reached, and their spoil deposited near the resting places of their quondam companions brought

at an earlier period through the Bewcastle Gap: that ice-stream having found, before it reached the Yorkshire coast, an ice-antagonist from Scandinavia that had deflected it to a similar focus.

CHAPTER VIII.

Population—Race.

Introductory—Populations of Civil Parishes and Townships—Necessity of keeping the Statistic of Males and Females Separate—Populations at different Age-Periods—Appendix—Former Inhabitants of Area—Racial Characteristics—Men of the Rough and Sharp-Stone Period—Men of the Smooth-Stone Period—Professor James Geikie—Dr. John Evans, F.R.S.—Chancellor Ferguson—Early History of Cumberland and the North of England—Long Barrows—The Old Lakes of Eden—The Two Races—Dolicocephalic—Brachycephalic—Dr. John Beddoe, F.R.S.—The Scandinavian Element in the Place-Names—The Isle of Man the Source of Norwegians—The Norse Element in the Place-Names of the Civil Parishes—Percentage of Norse Element—Canon Isaac Taylor—A. W. Moore—Isle of Man—The Lake District—Iceland—Dr. Beddoe's Opinions—The Colour of Eyes and Hair—The Proclivity to Phthisis—Cancer—Summary of Tables as to the Prevalence of certain Prevailing Colours in Eyes and Hair.

THE next subjects we have to consider are the populations of the area, and their racial characteristics; and as it is necessary for the further progress of this investigation that the results of the Census should be at hand, extracts from the Reports of the Census Commissioners have been given in the Appendix, where tables are given, containing the names of all the civil parishes and townships comprised within the boundaries of Cumberland, Westmorland, and the registration district of Ulverston in Lancashire, with their *male* and *female* population separately, at the censuses of 1871 and 1881 (Table I.).

The number of *males* and *females* living at different age-periods during the census of 1881 in the Registration Districts is contained in Table II.

In all statistics relating to disease, the necessity of keeping the sexes separate has already been dwelt upon, and is so self-evident as not to require repetition; however, when we discuss disease distribution in the concluding chapter it will be found that immediately the Graham-Farr *régime* at the General Register Office expired, a novel system of statistics was adopted, which, when explained later on, will account for the frequent warning given in these pages with regard to the separation of the sexes in all statistics relative to the human race.

Racial Characteristics.

Before discussing the scanty materials at our disposal with regard to the racial characters of the populations of Cumberland, Westmorland, and the Lake District, it will be well to summarize a few history-marks as regards the kinds of men that have from the earliest period, as far as we have ascertained, inhabited the north-western part of Great Britain.

In the first place we have (I.) the men of the *Stone* period, (II.) men of the *Bronze* period, and (III.) men of the *Iron* period.

The Stone period may be divided into (α) the *oldest* or *rough-stone age*, and (β) *the smooth-stone age.*

With the *Bronze* and *Iron* ages the history of man passes out of the domain of the geologist and enters that of the archæologist and historian. Professor Geikie says the weapons and implements belonging to the older period (the rough and sharp-stone age) are altogether of ruder form and finish. They are merely chipped into the requisite shape of adze, hatchet, scraper, or whatever the implement may chance to be. Although considerable dexterity is shown in the fashioning of their rude implements, yet they certainly evince much less skill on the part of the tool-maker than the relics of the later smooth-stone period.

It is noteworthy, Professor James Geikie remarks, that

while the implements of the smooth-stone period are made of various kinds of stones, those of the rough-stone, or oldest period consist almost exclusively of flint; and so characteristic are the shape and fashion of the latter, that an experienced archæologist has no difficulty in distinguishing them at once from the succeeding, or smooth-stone period. There is a gap in the succession of the two periods. As to the evidence of the former occupation of this area by these ancient peoples, I shall quote the words of the eminent archæologist, Chancellor Richard S. Ferguson,[1] who in his History of Cumberland tells us that up to the year 1890, no implements of the Palæolithic or rough-stone period had been found, either in *caves* or *river drift*, within the area of Cumberland, or, indeed, in the North of England. A *stone celt* found near Keswick, and two in the Carlisle Museum, have indeed been assigned to the Palæolithic period; but the better opinion is that they are unfinished implements of the Neolithic (or polished or smooth-stone) period. As Dr. John Evans suggests, there may be yet discovered in the gravel of the valley of the Eden *drift implements.*

Neolithic stone implements have been found in many places of the Cumbrian area, as the lists and descriptions given by Dr. John Evans, F.R.S., testify; *celts* or *hatchets*; the greater part are made of *felstone*, and some of a shape almost peculiar to Cumberland. *Perforated hammers* and *stone axes* are also very common. Of the three known examples of *celts* which have been found attached to their original handles, two are from Cumberland, one from the Solway Moss, and the other from Ehenside Tarn, in West Cumberland. *Stones for sharpening celts have also been found*, one at Lazonby having seventy grooves in it.

Several of the *long barrows* of the *Dolichocephalic*, or *long-*

[1] "A History of Cumberland," by Richard S. Ferguson, M.A., LL.M., F.S.A., Chancellor of Carlisle. Elliot Stock, 1890.

headed race, who used these stone instruments, are to be found in Cumberland. There is a fine one near "The Shaws," Gilsland; another called Sampson's Bratful is on Stockdale Moor in Copeland Forest.

Many relics of the *Brachycephalic* or *round-headed* race, who intruded themselves upon the *Dolichocephalic* race, have been found in Cumberland; but the *bronze celts*, *spear heads*, and *palstaves* of the brachycephalic men too readily found their way into the melting-pot of the brass-founder, and so are of rarer occurrence in the local museums.

The glaciers that at some time or other—most probably after the Palæolithic period—covered the area of Cumberland, must have completely changed the surface of the country; but the men of the *Polished-stone period* and of the *Bronze period* saw the country in its main features much as we see it now, though it is possible that three lakes or meres, at Lazonby, Langanby, and Appleby, occupied the valley of the Eden, and that the Petterill ran into that river at Great Salkeld and not near Carlisle, and perhaps that both joined the Caldew south of Carlisle instead of north, while the Waver, Wiza, and Wampool sought the sea by old channels, to which very little change of level would make them even now revert.[1]

Ferguson continues—we have already divided the early inhabitants of the land into two races—the one the earlier, *Dolichocephalic*, of the *Polished-stone period;* the other, the later, *Brachycephalic*, of the *Bronze period*—a Celtic race—a branch of that great Aryan family, which has peopled nearly all Europe and the great part of Asia, and which appears always to have possessed a knowledge of the use of metal. This *Celtic* race was, compared with their *non-Aryan* predecessors, a set of very ugly customers. Their bones, as dug

[1] "The Old Lakes of Eden," by J. G. Goodchild, F.G.S., Trans. Cumberland and Westmorland Soc. Part xiv.

up, prove them to have been bigger (their average stature over five feet eight inches), thicker, and more muscular; they had broad jaws, *turned-up noses*, high cheek-bones, wide mouths, and eyes deeply sunk under beetling brows, that overhung them like pent-houses, the superciliary ridges in their skulls tell that—characteristics in striking contrast to the short stature and mild and pleasant countenances which their bones show the *Dolichocephalic* men to have possessed. Armed with the superior weapons, the round-heads soon asserted their superiority over the long-heads. They did not annihilate them; in the *round barrows* of the round-heads both *long* and *round* skulls appear, and in the later *round barrows* the skulls begin occasionally to appear of an intermediate shape. This shows that the round-headed men of the *bronze* weapons enslaved the long-headed men with their *stone* weapons, and took the *long-headed* women for their wives. The language of the *round-headed* men swallowed up the language of the *long-headed*, and the land was in the possession of the Celts. How far the traces of the language spoken by these people survive in the place-names and dialect of the district is a moot question; that they do survive is undoubted, but the question is as to the degree. Mr. Robert Ferguson, F.S.A., is of opinion that there are no vestiges of a Celtic origin in the characteristics, physical and moral, of the present inhabitants of the district. Nor does their dialect present any but the faintest traces of the language of the ancient Britons. And though a more considerable number of Celtic names of places exists than in most other parts of England, yet, taking the district of the mountains, where ancient names usually linger much longer than elsewhere, the number of such names is, in point of fact, less than in some other mountain districts of England, as, for instance, Derbyshire.

Dr. John Beddoe has worked laboriously and well in his endeavour to discover what are the racial characteristics of

the present populations; and as whatever this observer undertakes is sure to be conscientiously carried out, the results of his labours, whatever they may be, are sure to advance science.

At the time of the Roman Invasion, according to Cæsar and Agricola, there were at least two races of natives in Britain. The fair-haired, round-headed, blue-eyed, tall, bony and muscular Kelt, who had invaded the home of the mild and peaceful long-headed men of the smooth-stone period; some of whom still survived in the north-west, and the little swarthy, black-haired and black-eyed, Cymric Kelt, who had invaded his fair-haired predecessor; then came the Roman *régime*, after which the country that Rome thought worth keeping for 400 years, became an attraction to the restless, discontented, enterprising, and hardy sea-faring men of the north, which were naturally divided into (1) those who occupied the iron-bound coast of Norway, its fiords and boisterous climates, from exposure to the full blast of the storms sweeping over the Atlantic; and (2) the *Danes*, who at home were less exposed than their northern neighbours and kinsmen. The former inured to their native storms seemed to rejoice in courting the dangers of the sea; and this dare-devil element in their character led them to the exploration of Greenland, Iceland, the Faroë, Shetland, Orkneys, Hebrides, the Isle of Man, and Morecambe Bay, Solway Firth; whilst their southern kinsmen traversed the North Sea, and made the Wash the earlier equivalent of the bays just named.

But after pursuing two very different courses, the two peoples met in Cumbria, where they left the names of the parishes and townships, as evidence to this day of their having once occupied the land they had wrested from their predecessors, and named it after their own fashion in their own language. The question that at once suggests itself to us is—The names of the hardy Norsemen are certainly amongst the fells, the rivers, the dales, the parishes and

townships; but has any of their blood descended to the people occupying these Norse-named habitations? That the names remain a reference to the list in the Appendix will at once convince those who have any knowledge of Norwegian and Danish place-names. With regard to the second part of the question, I shall refer to the facts which Dr. Beddoe has collected on this subject.

The Scandinavian Element in the Place-names.

To discuss fully the list before us would be to trench upon the historian's province; all therefore that will be attempted is to draw attention to the more salient facts contained in it, in the hope that they may not only interest but help us in our research. Before analysing the list referred to, it will will be well to quote what Dr. Beddoe[1] has said as to the colonization of this part of England.

The colonization, this author says, of the western coast, by the Scandinavians, chiefly Norwegians, from the Hebrides, Isle of Man, and the cities of the Ostmen in Ireland (Dublin, Waterford, Wexford), is, considering its importance and the late period at which it must have taken place, singularly obscure.

The settlement of Cumberland, Westmorland, Furness, and eastern Dumfriesshire has been studied by Ferguson, who is of opinion that it must have been effected from the Isle of Man. The facts we have to deal with are these:—

1. The history of Southern Cumbria (the modern Cumberland and Westmorland) remains very obscure after the seventh century, when we know it was under Northumbrian sway. Edred, an Anglian ruled at Carlisle in 918 A.D.,[2] but the population may have been still largely British, while the country lay very open to the raids of the Norsemen.

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[1] "The Races of Great Britain," by John Beddoe, M.D., F.R.S., Arrowsmith, Bristol; Trübner, London, 1885.

[2] Robertson's "Scotland under her Early Kings," vol. i., pp. 70, 71.

Raids of the Norsemen.

2. A.D. 945 Cumberland and Strathclyde, we are told, was harried with fire and sword by King Edmund, their king *Dunmail* (Domnhal or Dunwallon) expelled from the former if not from the latter region, and the country granted to the King of Scots, to be held by the English Crown. We may presume that the land was still sparsely inhabited.

3. A.D. 1000, Ethelred II. invades Cumberland ("Ubi Dacoram maxima mentio," says Henry of Huntingdon) and wastes the country.

4. When Malcolm Canmore ravaged Northumbria and swept away a great part of the remaining population of Yorkshire into slavery, Cumberland and Westmorland were his (at least the part north of the mountains which divide Lonsdale from Edendale), and the Cumbrians doubtless formed part of his army; moreover, Cumberland was the nearest and safest refuge for the Anglo-Danes of Yorkshire, when they were fleeing from the wrath of William the Bastard. (Note the large percentage of Norse names in the valley of Eden.)

5. Dolfin, son of Cospatrick, was Earl of Cumberland till William Rufus expelled him; but Waltheof his brother retained extensive Lordships therein. William introduced a colony of Saxons from the south, whom he settled in and about Carlisle.

6. We find the *local names* of Cumberland, Westmorland, Furness, Annandale and Eskdale for the most part Teutonic, and rather *Scandinavian* than Saxon, and rather *Norse* than *Danish*. The district is strongly tinctured with Norse characteristics; and the people while bearing a certain resemblance to the modern Strathclyde Wallians in stature and feature, approach more nearly, Dr. Beddoe thinks, in these respects to Norwegians, with whom they also agree in being remarkably fair.

7. The Isle of Man was in the possession of the Norsemen

for several centuries, and they have left their mark on the local names, customs, and laws of the island; but the language and the physical character of the people are "Celtic" to this day, though doubtless somewhat modified.

Cumberland lies opposite to Man, and is a much more fertile and desirable land. We may suppose, therefore, that a continual stream of Norse colonization poured, during the tenth and eleventh centuries, into the half-deserted mainland, to which the Isle of Man may have served as a kind of stepping stone; while the native Manxmen held strongly to their island, and thus perpetuated their race.

The period of Norse invasions and misfortunes was as important in Scotch as in English history, and was more protracted; for it may be said to have hardly ceased until the battle of Largs in 1261, or at the earliest the establishment of Sumarland as ruler of the Hebrides about 1150 A.D.

But then, as in England, the great invasions of the ninth century were, ethnologically, the most important. They made the Norwegians rulers of the Shetlands, the Orkneys, the Hebrides and Man; and from that time forth the coasts of Scotland were vexed by perpetual raids, while their chiefs at various times subdued and exercised dominion over Caithness and other portions of the mainland.

The Scandinavian Element in the Place-names.

The list of Civil Parishes and Townships, together with their populations may now be discussed.

The total number of distinct populations occupying the Civil Parishes and Townships in Cumberland, Westmorland, and the Ulverston registration district of Lancashire, amount to 346—of which Cumberland contains 209, Westmorland 109, and Ulverston 28.

These 348 place-names have been most kindly examined by my friend Mr. William Kneale, of Douglas, whose proficiency, after a long experience in Keltic and Norwegian

literature and archæology, entitles him to be considered one of our best authorities on such subjects. Mr. Kneale has copied out all the names having a distinctly *Scandinavian* character, and from the list with which he has furnished me, I find that they prevail in the thirteen Registration Districts of the area according to the following percentages.

Registration Districts.	Number of Civil Parishes and Townships.	Scandinavian Place-names.	Percentage of Scandinavian Names.
The Whole Area	346	118	34·1
Alston	—	—	—
Penrith	39	21	53·8
Brampton	19	3	15·7
Longtown	14	2	14·2
Carlisle	20	3	15·0
Wigton	31	12	38·7
Cockermouth	49	13	26·5
Whitehaven	24	6	25·0
Bootle	12	6	50·0
Cumberland	209	66	31·5
East Ward	30	12	40·0
West Ward	21	7	33·3
Kendal	58	20	34·4
Westmorland	109	39	33·9
Ulverston	28	13	46·4
Part of Lancashire	28	13	46·4

The Rev. Canon Isaac Taylor[1] alludes to the Isle of Man as the source of a great deal of the Norse blood in Cumbria.

[1] "Words and Places," Macmillan & Co., 1875, p. 115.

At one time this island formed a portion of the kingdom of Norway, and must have contained a considerable Norwegian population, as appears from the Norse names of the villages, such as *Colby*, *Greenaby*, *Dalby*, *Baleby*, *Kirby*, *Sulby*, *Jurby*. On the coast we find the bays of *Perwick*, *Fleswick*, *Greenwick*, *Sandwick*, *Aldrich*, *Soderick*, *Garwick* and *Dreswick*; the capes of *Langness* and *Littleness*, and the islands of *Eye*, *Holm*, *Calf* and *Ronaldsay*; while *Sneefell* (Snow Hill) the highest mountain, bears a pure Norwegian name. Canon Taylor gives a map in his work by which he shows that after the victory of Godred Crovan, his Norse followers went to the south of the island, and left the north to the Manx. This may have been the case in the early part of Norse influence; but if we take the place-names as evidence of occupation, we shall find that no such distinction really exists, but that the Norwegian element is discoverable all around the coast, and up every valley that opens upon a creek.

Through the aid of Mr. A. W. Moore's work on the "Surnames and Place Names of the Isle of Man,"[1] I have calculated that there are about 2,014 place-names in the Isle of Man, of which 268 have a *Norse* origin, either wholly or partially, which gives a percentage of 12·7; of these 20 names end in "by," or 7·4 per cent.; whilst the coastal features are known by 66 different Norse names from the Point of Ayr to the Calf of Man: these characteristic remains of the Norse invaders, therefore, amount to nearly 25 per cent. of the whole list.

Canon Taylor, referring to the peopling of the Lake District by the Norse people from the Isle of Man, remarks that the *Danish* names in England are seen to radiate from the Wash; so that the Norwegian immigration seems to have proceeded from Morecambe Bay and that part of the coast which lies opposite to the Isle of Man. Cumberland,

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[1] Stock: London, 1890.

Westmorland, Lancashire, and Dumfriesshire contain a very considerable number of Scandinavian names, but comparatively few of a distinctive Danish cast.

The Lake District seems to have been almost exclusively peopled by Celts and Norwegians. The Norwegian suffixes, *-gill*, *-garth*, *-haugh*, *-thwaite*, *-force*, and *-fell*, are abundant; whilst the Danish forms, *-thorpe* and *-toft* are almost unknown; and the Anglo-Saxon test words, *-ham*, *-ford*, *-worth*, and *-ton* are comparatively rare.

Of the other test words we find *-holm* in *Lingholm* and *Silverholm* on Windermere, and in *Rampsholme* on Ullswater. The suffix *a*, which denotes a river as well as an island, appears in the river names of *Greta*, *Liza*, *Wiza*, *Rotha*, *Bretha*, *Rathay*, *Calda*, as well as in the *Ea* and the *Eamont*. *Ness* occurs in the names of *Bowness*, *Shinburness*, *Scarness*, and *Furness*: *wick* in *Keswick*, and *Blowick* on *Ullswater*. The Norwegian word *Stackr*, a columnar rock, was appropriately applied to the mountains which bear the names of *Stake*, the *Sticks*, *Pike o' Stickle*, and the *Hay-Stacks* (high rocks). More than 150 different personal names of the Icelandic type are preserved in the local topography of the Lake District. According to the last census (Canon Taylor's work was published in 1875) there are now only sixty-three surnames in Iceland, of which the commonest are *Kettle*, *Halle*, *Ormur*, and *Gils*. In Cumberland and Westmorland these are preserved in the local names, *Kettlewell*, *Hallthwaite*, *Ormathwaite*, and *Gellstone*. By far the most common Christian names in Iceland are *Olafur* (borne by 992 persons), *Einer* (by 878), and *Bjarni* (by 869). These are found, according to the same author in *Ulverston*, *Ennerdale*, and *Barney House*. We find the name of *Hrani* (now Rennie) in *Ransdale*, *Rainsbarrow*, and *Wrenside*; *Loki* in *Lockthwaite*, *Lockholm*, *Lockerby*, and *Locker-Barrow*; *Buthar* in *Buttermere*, *Butterhill*, and *Butter Gill*; *Geit* in *Gateswater*, *Gatesgarth*, and *Gatesgill*; and *Skögul* in *Skeggles Water*. The Norse

haugr, a sepulchral mound, is often found in the names of mountains crowned by conspicuous tumuli. The name of the old Viking who lies buried beneath is often preserved in the first portion of such local names: thus, *Silver How*, *Bull How*, *Scale How*, and *Butterlip How*, are probably the burial-places of the forgotten heroes, *Sölvar*, *Böll*, *Skall*, and *Buthar Lipr* (Taylor, p. 116).

So far these names tell us of the former occupation of this area by people of Norwegian origin. But we must ask ourselves the question, Does the Norse blood still run in the veins of those who now inhabit these places? The mountains remain and their names remind us of the people that first gave their names. The parishes and townships still are known by the same names that their Norwegian founders and builders gave them; but still the question again arises, Does the blood of the founder and builder still give evidence of descent to the present generation? This is the all-important point to be discovered by the medical man. The history of the place-names is highly interesting, but it is of little value unless it is made subservient to the purpose we have in view—that of tracking the racial characters of the present generation backwards to their remote origin. The names of places are the slots, or the scent that give us the clues to our quarry; but when we reach the ground where we expect to meet it, we find in too many cases such a mixture of racial phenomena, that it becomes an almost impossible task to distinguish those we are in search of. Nevertheless we know from the works of ancient historians that the Keltic, Scandinavian, and other early inhabitants of these parts had certain physical characteristics by which they could be known: and further, that the direct descendants from these peoples, in countries where their blood has met with little intermixture, have physical features corresponding with those described by historians. It becomes, therefore, possible to trace the descent of these characters, when existing, by

accurately noting what we observe in the representatives at the present time of earlier populations occupying certain localities still bearing the original names of their founders. Dr. Beddoe, whose investigations cannot fail to be highly valued by the medical profession, has, in the work already quoted, given us the result of his investigations in the form of elaborate tables, which will be found in the Appendix.

I have, however, made a summary of the facts contained in these tables, which will perhaps help to introduce the subject to those who have not as yet made a study of it.

Racial character, as expressed by the colour of the *hair* and *eyes*, has been studied by Dr. Beddoe throughout the British Isles ; we shall, however, confine ourselves to the results that he obtained within the Cumbrian and Lake area. Dr. Beddoe thinks that the predominant elements in the Cumbrians are *Norse* and *Kymric*, especially the former ; Danes and Angles are also represented, and Gaels and Saxons to a less extent probably. He further remarks that William Rufus brought a colony from the south to Carlisle and neighbourhood. Dr. Beddoe further states that he has always held strongly to the idea that the Norwegians filtered in from the Isle of Man. With regard to the proclivity to certain diseases, the same author observes that his figures did not show *blondes* as more liable to *Phthisis* than people with *dark* hair and eyes ; but he thinks that people with fine, thin, transparent *skins* are very liable to it: but, he adds, his figures do not yield any evidence on the point. Although he should say that people with *fine* skins, *blue* eyes and very *dark* hair are most liable with regard to *Cancer*, he has no doubt on his mind that *black*-haired people are most frequently attacked, and that the *red*-haired rank next.

With these few remarks I will close this brief chapter by subjoining the results of Dr. Beddoe's investigations in this area :—

1. Dr. Beddoe examined two thousand two hundred and ninety individuals.

2. Of these 2,290 (males and females)—

67·17	had	Light Eyes.
13·27	,,	*Intermediate*, or *neutral* in colour, Eyes.
19·87	,,	*Dark* Eyes.

3. Of the *Light* Eyes—

4·67	had	Red	Hair.
17·80	,,	Fair	,,
34·99	,,	Brown	,,
9·22	,,	Dark	,,
66·68			

4. Of the *Intermediate* or *Neutral* Eyes—

·35	had	Red	Hair.
1·26	,,	Fair	,,
5·21	,,	Brown	,,
4·71	,,	Dark	,,
11·53			

5. Of the Dark Eyes—

1·12	per cent.	had	Red	Hair.
·91	,,	,,	Fair	,,
6·22	,,	,,	Brown	,,
11·66	,,	,,	Dark	,,
19·91				

Totals.

Light Eyes	66·68
Intermediate Eyes ...	11·53
Dark Eyes	19·91
	98·12

Red Hair	6·14
Fair „	19·97
Brown „	46·42
Dark and Black Hair ...	25·59
	98·12

In our clinical notes on cases, we should never omit to record such personal, physical characters as the above; bearing in mind that they are always more or less intimately associated with what we know to exist in highly organized beings, however incapable we may be of defining them,—the powers to resist or the tendency to yield to certain forms of disease—powers which we sum up in the terms *Insusceptibility* or *Susceptibility*, or *Constitutional tendency*.

Such personal characters are as necessary in the history of a case as are the physical, chemical or other characters of the soils, climates, and configuration of the localities where the diseases we have to study have been contracted.

CHAPTER IX.

LOCAL METEOROLOGY AND CLIMATOLOGY.

Atmosphere and Currents—Prevailing Winds—Irish Sea—Isle of Man—Cumbrian Coast well Air-flushed—Moore on Manx Winds—Dr. A. Buchan on Prevailing Winds of Scotland—Force of Wind and Phthisis—Horizontal and Vertical Deflection of Winds—Scarborough—North Devon—St. Bees Head—Wind-force Fatal to the Consumptive—Winds and Malaria—The Importance of a Knowledge of Winds to the Medical Practitioner—Malarial Rheumatism and Heart Disease—Winds from the Sea—Direction of Coastal River-Valleys—Monthly Prevalence—Winds from the Land—Inland Natural Boundary—Protective Influence of—Alston Outside it—Easterly Winds Passing over Barrier get Purified—The Greek Ether and Air—Zeus—The Helm Wind—Cloud-caps—Æacas—Oros—Mr. William Marriott's Report on "The Helm Wind"—The Importance of Studying Currents of Air in Lee-ward Valley Systems—Local Climates—The Rainfall—Mr. Symons' List of Stations and Approximate Mean Rainfall at each—Rainfall and Altitude—Distribution of Rain—Wasdale and Borrowdale—Isle of Man and Scotland—Influence of Concussion—Entanglement—Kendal, Mr. Isaac Taylor, F.R.S., Average Twenty Years—Mr. Fletcher M.P.—"Symons' British Rainfall"—Mr. Symons on the Rainfall in the Lake District—Table Illustrating his Remarks—Mr. Benn—Quinquennial Periods—Table of Monthly Rainfall—Maximum and Minimum Rainfall—Temperature, Dewpoint, Rainfall, and Wind—Table—Seasons—Temperature and Rainfall—Mr. G. J. Symons, F.R.S.—His Ratio of the Rainfall in each of Twenty-two Years to Mean of whole Period 1845–1866—Table—Table of Rainfall—Monthly Percentages at Twenty Stations in the Lake District—Mr. Frederic Gaster—Mean Monthly Values—Tables—Rainfall in 1868—Ullswater—Haweswater—Western Lake District—Compared with the Eastern—Table—Altitude and 1868 Rainfall—General Conclusions—Sun—Sunshine Observations—Mean Temperatures, etc.—Deaths by Lightning—Barometer—The Climate of the Microphyte.

The Atmosphere and its Currents—Prevailing Winds.

AS the atmosphere is the medium in which we live in common with all other land animals, it is evident that all concerning it must be of the utmost importance in

any discussion on health or disease. But as the aërial envelope of our planet is the field in which all meteoric and climatic phenomena are displayed, we must make a selection from the vast multitude of interesting subjects around us, and confine ourselves to the consideration only of such grand features as have been acknowledged for ages to exert a powerful influence on man and his lower companions. First and foremost are the movements of our atmosphere. In a former chapter the effect of even the temporary absence of winds (calms) (p. 6) has been adverted to, and will again be incidentally referred to in the course of this chapter. This subject is so full of interest, that we are tempted at the very threshold of our discourse to wander off and point to the many wonderful phenomena that surround it and are more or less associated with the causes and effects of the air-currents that daily sweep over us; but we must pass these by, and refer our readers to works especially devoted to Meteorology and Climatology, and limit ourselves to a discussion of the facts connected with aërial currents and their relation to disease distribution, as far as Cumberland, Westmorland, and the Lake District are concerned.

The Prevailing Winds.

If we take a chart of the Irish Channel, we shall find that the Cumbrian area forms a part of the eastern boundary of an irregular parallelogram of sea, bounded on the north by Scotland, and the elevated land of Wigton, Kircudbright, and Dumfries; on the west by Ireland, and the mountains of Down and Wicklow; on the south by North Wales, including Anglesea, Snowdonia, Denbighshire, and Flint; whilst in the centre of this wide expanse of sea-water between the Cumberland mountains, and the Mourne mountains in County Down, lies the Isle of Man, with its beautiful towering ridge of heights stretching for 30 miles from north-east to south-west, and culminating in Snaefell, which reaches a height of

2,034 feet, *in medio cursû* between Britain and Ireland, as Cæsar described this wonderful little rock-island, Mona (maen = a rock); which not only influences the tidal wave in the Irish Channel in a most remarkable manner, but the lower currents of the prevailing winds as they sweep over the sea surface in their passage towards the Cumbrian coast.

Fortunately for Cumberland it is fully air-flushed by sea winds on its western side; in fact, it may be said that all the parts distinguished by the *dark* and *light blue* inter-contour areas are fully exposed to the currents of air that come to them straight from the bosom of the Irish Sea; and these, it must be remembered, are the most thickly populated localities. (See Contour Map.)

Let us for a moment study the winds observed at the extreme points of the Isle of Man, as given by Mr. A. W. Moore, M.A., F.R. Met. S., in his elaborate and excellent work on "The Climate of the Isle of Man." [1]

The Isle of Man Winds.—Mr. Moore gives the observations made at the Point of Ayre and Calf of Man lighthouses for 1831–47, first published by Cumming, in his work on the Isle of Man. His tables show the following frequencies :—

N.,	23·1 days.	S.W.,	59·1 days.
N.E.,	20·2 ,,	W.,	38·8 ,,
E.,	21·0 ,,	N.W.,	38·7 ,,
S.E.,	39·0 ,,	Calm,	10·4 ,,
S.,	27·1 ,,	Variable,	59·1 ,,

Total . . 336·5 [2]

These are the means of the two lighthouse stations, one, The Point of Ayre, at the extreme north-east, and the other, The Calf of Man, at the extreme south-west.

Dr. Alexander Buchan, M.A., F.R.S.E., in a valuable article

[1] Published by James Brown & Son, Douglas, Isle of Man, price one shilling.

[2] If we allow the "variable, 59·1", there are still 28·5 days unaccounted for.

on *The Prevailing Winds of Scotland*,[1] not only includes the Isle of Man, but gives us the data from stations in Dumfriesshire, and other places in the South of Scotland, which affect the Cumbrian coast.

The General Direction of the Wind for Scotland.

It will be well, in the first place, to give some idea of the general direction of the winds in Scotland as observed by Professor Piazzi Smyth, Astronomer Royal for Scotland, and quoted by Buchan in his paper. The following table is the result of reducing the observations at fifty-five stations for each month; and considering the number and various positions of the fifty-five stations, the result may be held as pretty fairly representing the general direction of the wind for Scotland, the local peculiarities of one place being, in the opinion of Dr. Buchan, who is the chief authority on all such matters in Scotland, counterbalanced by those of another.

Table showing the Prevailing Winds in Scotland on an average of fifteen years at fifty-five stations :—

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm or Variable
January .	2	2	2	3	4	7	6	3	2
February .	2	2	2	3	3	6	5	3	2
March . .	3	3	4	2	3	5	5	4	2
April . .	2	3	4	3	3	5	5	3	2
May . . .	2	3	5	3	3	5	5	3	2
June. . .	2	2	4	3	3	5	6	3	2
July. . .	2	2	3	2	3	6	7	3	3
August . .	2	2	2	3	3	7	6	3	3
September.	2	2	2	3	3	7	6	3	2
October .	2	2	3	3	3.	6	6	3	3
November .	3	2	2	3	3	5	5	4	3
December .	2	2	2	3	3	8	6	3	2
Year .	26	27	35	34	37	72	68	38	28

[1] *Journal of the Scottish Meteorological Society*, March, 1872. New Series, No. xxxv. pp. 293–303.

The Scotch station of the greatest importance to the Cumbrian area is the one at Cargen, Kirkcudbrightshire. It is situated on the right bank of the river *Nith*, just about where the letter T in the word "isotherm" occurs to the west of "July isotherm," where it crosses the 55° N. LAT. in the *contour map;* it lies therefore to the south of the southern Uplands, where the winds are subject to be influenced by the trend from west to east; nevertheless, as this line of heights merges into the Cheviot Hills on the east, the table is useful in showing how the deflected winds influence the areas towards which they blow, as, for instance, the flat parts of the districts of *Wigton*, *Carlisle*, *Longtown*, and *Brampton*.

Dr. Buchan gives the following data from observations made at the Calf of Man and Cargen, which I place side by side for the sake of comparison :—

	N.		N.E.		E.		S.E.		S.		S.W.		W.		N.W.		VAR. OR CALM.	
	Calf of Man.	Cargen.	Calf of Man.	Cargen.	Calf of Man.	Cargen.	Calf of Man.	Cargen.	Calf of Man.	Cargen.	Calf of Man.	Cargen.	Calf of Man.	Cargen.	Calf of Man.	Cargen.	Calf of Man.	Cargen.
JAN.	2	4	2	2	2	4	4	3	5	2	6	4	5	7	2	4	3	1
FEB.	2	4	1	2	3	3	4	2	3	2	6	4	4	7	2	4	3	0
MAR.	3	4	2	3	4	6	3	3	2	2	4	3	3	5	6	5	4	0
APR.	3	3	2	3	4	5	4	4	3	2	4	3	3	6	2	4	5	0
MAY	3	3	2	2	5	6	4	5	4	3	3	3	3	5	2	4	5	0
JUNE	5	3	1	3	2	2	3	3	4	3	4	4	4	6	3	5	4	1
JULY	3	4	1	2	2	2	2	2	4	4	7	4	3	8	3	5	6	0
AUG.	3	4	1	2	2	2	2	2	4	4	5	5	4	7	4	5	6	0
SEPT.	2	3	2	2	3	2	3	2	5	3	6	5	4	7	2	5	3	1
OCT.	2	5	1	2	5	2	4	5	3	2	4	3	4	6	4	5	4	1
NOV.	2	7	3	2	3	3	5	2	2	1	3	3	4	6	4	5	4	1
DEC.	3	5	1	3	2	2	4	3	4	2	6	4	5	8	3	4	3	0
Year	33	49	19	28	37	39	42	36	43	30	58	45	46	73	37	55	50	5
	$\underbrace{\qquad}_{41}$		$\underbrace{\qquad}_{23}$		$\underbrace{\qquad}_{38}$		$\underbrace{\qquad}_{39}$		$\underbrace{\qquad}_{36}$		$\underbrace{\qquad}_{52}$		$\underbrace{\qquad}_{59}$		$\underbrace{\qquad}_{46}$		$\underbrace{\qquad}_{27}$	

If we place the means of these two stations in comparison with those of Scotland, we shall be able to see why they differ :—

Winds.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Var. or Calm.
Scotland	26	27	35	34	37	72	68	38	28
Cargen and Calf of Man . . .	41	23	38	39	31	52	59	46	27

In the first place, the great preponderance of S.W. and W. winds in Scotland is coincident with the free exposure of the west of Scotland to those winds from the Atlantic without interruption. These winds in the Irish Sea have, however, to suffer deflections by being forced against Ireland and the Isle of Man.

The direction of the Valley of the Nith from the north to south would naturally give a northerly direction at Cargen to some of the Westerly winds from W. to N.; and again at the Calf, the steep precipitous cliffs, from Peel to the south-west point, would give the winds from W. to N.W. a local northerly direction; and thus, although the winds are recorded N., they are not really so. This is obvious, and may be thought hardly worth noticing, but we must remember that the *force* of wind is coincident with a high death-rate from *Phthisis* wherever it is found that a community more or less tainted with tuberculosis of the lungs, is exposed to it. There is no exception throughout the British Isles. Wherever the sea-winds come straight without any interruption that breaks their force, such winds are fatal to the consumptive exposed to them; this was abundantly proved in the first edition of this work (1875), and is confirmed in chapter x. of the present edition, in which a fresh decenniad of facts has been added. This force is partially broken when *horizontal* deflection takes place, as in the conversion of a N.W. surface-current into a northerly one; but it is completely broken when *vertical* deflection takes place, as against the face of steep-to cliffs, as those on the coast of Scarborough

or North Devon; in the former case the air-currents are deflected upwards to a great height in proportion to the strength of the sea wind, and act as barriers to the currents behind them, and in fact actually protect from their force the areas to the lee of the barrier. This is well seen at Scarborough, where this phenomenon may be observed in great perfection, and coincident with this steep-to coast the districts skirting it have a remarkably low mortality from *Phthisis*. With the exception of just to the north and south of St. Bees Head there are no steep-to cliffs protecting the Cumbrian area. In the coastal districts before us we shall find the highest mortality from consumption occurring in the districts most exposed to the full force of the winds, having a wide expanse of foreshore offering no resistance to the full access of the winds from the sea.

Whilst these winds have such a fatal effect upon persons afflicted with *tuberculosis of the lungs*, they appear to have an equally destructive effect upon malarial[1] emanations from the soil affecting local climates, such, for instance, as on the *malaria* that contains the germs (*pathogens*) of those forms of rheumatism which are concerned in the genesis of the fatal diseases of the heart that so materially swell the death-rate under this heading in certain districts in Great Britain that are *protected* from the influence of their purging and malaria-destroying powers. To this I have already alluded, and shall again have an opportunity of demonstrating the facts when discussing the map of the Geographical Distribution of *Heart Disease* in the Cumbrian and Lake District.

With regard to the *winds*, the important facts for the medical practitioner to know, regarding any locality about which he is consulted, are (1) that it is either exposed or not exposed to certain sea-winds; (2) that, if coastal, the sea-cliffs deflect the sea-winds vertically, or that the low-sloping foreshores favour the free access of such winds with-

[1] See note p. 235.

out breaking this force; (3) that, if inland, the configuration of the surrounding land, as shown by *contour maps*, like the one illustrating this work, is such as to shut out the *prevailing winds*, in consequence of the river-valley systems having their axes more or less at right angles to the prevailing direction; so that these winds are forced to blow more or less *over* the inhabited portions of such valleys; or that these valley systems correspond, more or less, as regards their axes, with the directions of the prevailing sea-winds, from their estuarine expansions at the coast-line to the highest parts of their water-sheds at the line of the water parting.

With these facts before him, the medical adviser will be enabled to decide, (A) that certain localities where the full *force* of the prevailing winds is experienced are unfavourable, to both *males* and *females* throughout Great Britain who are subject to tubercular disease of the lungs (*Phthisis*); and that, on the other hand, certain localities (where, by the configuration of the land, the *force* of the prevailing winds is broken, and the atmospheric air-currents descend into the lee-ward valleys, deprived of that obnoxious quality, but retaining all their *purity*), are favourable to the phthisical, and that their local climates, as proved by my investigations throughout north and south Britain, enable the *phthisical* to live over certain critical periods of their disease, and thus give them a chance of ultimate recovery, or at least of an extension of life.

(B) The medical adviser will also be enabled to decide what localities are purged, more or less completely, of foul residual air and *malarial* emanations; chief among the latter in Great Britain being the *malaria* concerned (as just stated) in the genesis of that many-headed group of diseases, known as *rheumatic*, that is associated with those diseases of the heart, which swell the national death-rate from the causes attributed to Heart Disease and diseases of the circulatory system.

Malarial rheumatism, like many other malarial diseases, does not bestow immunity from future attacks. When once it has found a home in the human body it remains there, latent, it is true, perhaps for months or years, as long as it finds no incentive to re-develop, but ready at a moment's notice to start with vigour, and too frequently with a vigour fatal to its host, immediately that the surroundings and their re-inforcements stimulate it to fresh life and activity.

The map of Heart Disease tells its own story of the winds, for when we see the districts so coloured (*red*) as to indicate a *low mortality* from this cause, then assuredly will we find the configuration of the land such as to facilitate the free air-flushing of the district, over which the prevailing winds pursue their unimpeded course; whilst on the other hand, where the country is honeycombed with pent-up stuffy hollows, from which the anti-malarial and the other physical properties of the sea-air are shut out, there invariably are to be found the highest death-rates from this group of causes.

NOTE.—The term *malaria*=bad air, is used to denote such masses of atmospheric air as are contaminated by the presence of disease-producers; such as *microphytes*, etc., that have found a soil in decomposing and decomposed animal and vegetable matter.

The Winds from the Sea.

Let us presume, in the absence of any reliable data from the area under discussion, that the observations made in the centre of the Irish Sea and in the south of Scotland do give us a clue to the prevailing winds which reach the Cumbrian coast. In the first place we have seen that that coast has a sloping foreshore, and that the inter-contour areas of *dark* and *light blue* prove that the land slopes up inland and thus gives free access to the atmospheric currents that reach the coast line. In the second, let us examine the tables of wind direction given on p. 231, and ascertain what are the prevailing winds. By these tables it is seen that out of the 365 days in a year, 36·

are characterized by the S. wind, 52 by S.W., 59 by the W., and 46 by the N.W., in all on 193 days the most purging and the most oxygenating wind, because the strongest and most ozoniferous, predominate on the coast-line that borders the beautiful area of Cumberland and the Lakes. Let us now examine the valley systems on the contour map, and see if their axes correspond to the direction of these winds.

Beginning with the estuary of the river Kent (*Kendal*), we shall take the river valleys as they open upon the sea in succession, until we reach that of the Solway Firth, and append to each valley the general direction of its axis :—

Morecambe Bay	S.W.	
River Kent...	S.W.	
„ Leven	S.	*Windermere and Coniston.*
„ Duddon	S.W.& S.	
„ Esk	S.W	*Eskdale and Wast Water.*
„ Ehen	S.S.W.	*Ennerdale Water.*
„ Derwent	S.W.	
„ Ellen	S.W.	
„ Waver	N.W.	
„ Wampool	N.W.	
„ Eden	N.W.	
„ Line & S. Esk	W.& N.W.	
Solway Firth	W.	

With regard to the monthly frequency of these air-flushings the following figures will give us some idea.

The least and greatest monthly number of days each of the above winds blew over the Cumbrian and Lake District coast-line.

Wind.	Least Number.		Greatest Number.		
S.	November	1·5 days.	September	4·0 days,	mean 2·7.
S.W.	November	3·0 „	July	5·5 „	„ 4·2.
W.	May	4·0 „	December	6·5 „	„ 5·2.
N.W.	January	3·0 „	March	5·5 „	„ 4·2.

So that each of the valleys, the axes of which are in the direction of the above sea-winds, are purged of their *malaria* and residual air, varying according to the wind, from 2·7 to 5·2 days every month throughout the year, or about once a week.

The Winds from the Land.

Although all winds that come to Great Britain are more or less sea-winds, those that reach our area over the Great Pennine Chain, or its natural inland boundary, may, in contradistinction to those just discussed, be called *land winds* or at least "*winds from the land.*" They are the *N.*, *N.E.*, *E. and S.E.*; these winds are of bad repute in the estimation of the public and the medical profession; as a rule they are drier, colder and contain less ozone. The *crimson* line on the contour map of the natural inland boundary of the Cumbrian and Lake Districts, marks the course of the barrier that exists against the direct invasion of these unpopular atmospheric currents; the only district not under its protective influence being that of *Alston*, which naturally has nothing to do with Cumbria at all; it is physically and hydrographically Northumbrian, as the contour map shows it lying on the eastern side of the great water-parting, and presenting the only exceptional opening to any of the above winds that exists in the whole thirteen districts: the valley of the South Tyne which is seen to loop upwards and be fully open to the ingress of the northerly winds.

The reader is referred to chapter iii., p. 54, for a description of the course of the natural inland boundary line; but it will be well to repeat some necessary facts.

During the course of this elevated boundary line from north to south, it gives protection to all the inland districts, if not to the whole area, except Alston, from the North and

East winds, to the extent that the lengths and heights given above (p. 56) indicate.

These winds, according to the table adopted for the sea winds (p. 231), prevail annually as follows :—N. 41, N.E. 23, E. 38, and S.E. 39 days = 141.

With the solitary exception of the district Alston, pointed out above, these winds are entirely shut out from the valley systems of the Cumbrian and Lake area. If, however, we take a physical or coloured contour map of England, we shall find that the easterly and south-easterly, after blowing over the central plain of England, would be diverted by the highlands of North Wales, and forced to round the southern end of the Pennine Chain, and make their way over the lowlands of Cheshire and Lancashire to the Lake District, where they would be registered as S. winds; now much of what are called East winds in England are really North-East winds changed to East by the rotation of the earth over which they have to pass on their way to the equator, so that in fact a N.E. starting from its home at a slow rate would, as it approaches the latitudes of Britain, be found lagging as the earth's mileage of *rotation* increased each second, and be left to cross the centre of England as an E. wind, some of which may be finally diverted by the Welsh mountains up through the channel between them and the southern end of the Pennine Chain, into a S. wind, and thus reach Morecambe Bay and the central Lake Districts. The natural boundary of the Pennine Chain more or less impedes all the winds from N. to S.E. from thoroughly purging the valley systems of residual and malarious air, as the winds from the sea have been shown to do.

Whilst this elevated boundary protects the country to its leeward from much of the *force* and other obnoxious properties of these winds, it also has a *purifying* effect upon them, for they are forced up along its windward flanks high up into the air to a mean height of 1,695 feet (p. 56), where

the low surface-currents of the easterly winds, after sucking up the impurities hovering over town and country, are made to mingle with the pure mountain air in all its vigour and purity, which must have a beneficial effect upon the used up and effete atmospheric currents that, before reaching our shores, had been rendered noxious by sweeping over the continent of Europe with its almost innumerable towns and villages, factories, and stretches of malarial land. After crossing the great barrier, these air currents descend into the valleys, purified and modified, and perchance robbed of much of their obnoxious character.

No wonder those ancient nature-watchers, the early inhabitants of Greece, drew a broad distinction between the *upper* and the *lower* strata of our atmosphere; the former of which they considered pure and fit for their Olympian gods, calling it *Ether* (αἰθήρ), and Zeus, the dweller in ether (αἰθεριναίων), according to Homer (Il. ii. 412; Od. xv. 523); whilst to the lower stratum in which floated vapour, fogs, clouds, dust, motes and haze, they applied the term air (ἀήρ). Mountain ether to these quick-witted, sensitive lovers of natural beauty was a delight, which stimulated their active brains, whilst it invigorated their limbs, and sent a thrill of enjoyment throughout their systems, that made life, health, vigour worth living for; no wonder then that their ideas of physical and mental perfection were associated with the medium in which they supposed their gods to live; and thus when they represented their deities in sculpture, they strove to give them the most perfect forms that men and women could be conceived to possess.

The Helm Wind.—Connected with the struggle of the winds under discussion to pass the Great Pennine barrier, and descend into the valleys on its western side, is an interesting phenomenon, which has been called "*The Helm Wind.*" The capping by clouds of well-known peaks and mountains has from time immemorial been observed, and

connected from the earliest times with changes in the weather.

In a former work[1] I have given some instances of the use for weather-forecasting of these mountain cloud-caps, amongst which I have selected the following. "Do not prophesy unless you know," seems to have been a time-honoured precept in very early times, and evidently acted upon, as the subjoined incident will show.

In the island of Ægina there is a remarkable conical mountain, called in Greek "the mountain" *par excellence* (*ὄρος*, now St. Elias), whose summit at the approach of rain was generally observed to be enveloped in a mist, thus affording to those who were aware of the phenomenon an opportunity of foretelling the approaching change. During the reign of "just and pious," King Æacus, a serious drought affected Greece: the Delphic oracle was consulted, and it proclaimed that it would not be stayed unless Æacus would pray to the gods and urge them to deliver his people and neighbours from the calamity. Æacus was aware of the significance of this phenomenon on Oros, and when informed of the purport of the oracle, seemed in no hurry to begin his prayers, which necessarily astonished and angered those suffering from the drought; he pursued what was in later times known as a *Fabian* policy—he delayed, but kept his weather-eye on the mountain, and waited, in fact, until he could just discern a slight mist on the mountain's summit; no sooner did he see this, than (without letting his people know his secret) he hurried away to the temple where he had in great haste summoned the people, and began in accordance with the oracular dictum to pray lustily to Jupiter for rain. The king's prayers were answered, abundant rain fell, and the drought was succeeded by plenty.

The *Helm Wind* had been noticed by several observers from

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1 "Climate, Weather, and Disease." London, 1855, p. 100.

time to time; but until the interest in it created by the Rev. J. Brunskill's paper, read before the Royal Meteorological Society, 18th June, 1884, entitled, "The Helm Wind," induced the council of that society to appoint a committee to collect information on the subject, the phenomenon had not been systematically investigated. The report of that committee was admirably drawn up by Mr. William Marriott, F.R. Met. Society, and printed in the *Quarterly Journal*, vol. xv., No. 70, April, 1889, p. 103.

From this instructive and valuable document I shall append a few extracts, which it is hoped will not only instruct my readers, but stimulate further investigation in this and other kindred phenomena. Mr. Marriott first describes the contour of the country; but before quoting from his report I will indicate as well as I can where *Cross Fell* can be found on the "Contour Map."

Cross Fell (2,930 feet) lies in the eastern part of the *Penrith* District, on the *crimson* inland boundary line (North Pennine Chain), about seven-eighths of a mile from the point where that line crosses the dotted county boundary between the *Penrith District* (Cumberland), and the *East Ward District* (Westmorland); and its site on the contour map lies to the S. by W. of the letter H, in the name of the district PENRITH, within the shaded inland boundary of the Lake District.

Mr. Marriott begins his report by remarking that the Cross Fell range of mountains forms part of the Pennine Chain, which runs from north-north-west to south-south-east. The range from Hartside Fell on the north to Hilbeck Fell on the south is high and continuous, and is not cut through by any valley. Behind this range on the east there is a high mass of land deeply cut by dales and valleys, but the tops of the mountains form a high table-land. Cross Fell is 2,930 feet; Dun Fell, 2,780 feet; Dufton Fell, 2,292 feet; and Hartside Fell, 2,046 feet above the sea-level. On the west is the Vale of Eden, a plain of some twenty miles broad,

extending to the hills in the Lake District. From the top of the mountain to the plain on the west there is an abrupt fall of from 1,000 to 1,500 feet in about a mile and a half. At the southern end of the range the fall is but slight, there being a gradual fall of from 800 to 900 feet in five miles from Hilbeck to Winton.

At times when the wind is from some easterly point, the *Helm* forms over this district, the chief features of the phenomenon being the following:—

A heavy bank of cloud rests along the Cross Fell range, at times reaching some distance down the western slopes, and at others hovering just above the summit; while at a distance of three or four miles from the foot of the Fell, a slender roll of dark cloud appears in mid-air, and parallel with the Helm Cloud. This is the *Helm Bar*. The space between the Helm Cloud and the Bar is usually quite clear, while to the westward the sky is at times completely covered with cloud. The Bar does not appear to extend further west than about the river Eden. A cold wind rushes down the sides of the Fell and blows violently till it reaches a spot nearly underneath the *Helm Bar*, when it suddenly ceases.

As already stated, the wind blows strongly down the Fell sides until it comes nearly under the *Bar;* it then rushes upwards, and so produces a calm beneath the *Bar*. The air in rushing upwards draws the air inwards and upwards along with it on the other or western side. This accounts for the westerly wind which blows on the western side of the Bar. Further westward, away from the influence of this eddy, there should be a *downward* current from the eastward. This has been confirmed by observations made by Mr. Dent on April 21st, 1888. Mr. Dent, of Street House, thus reports:—

As he left home about 9 a.m. for Appleby market, the wind at that point was furious from north-east, and seemed to *fall down* upon him. When he got to Bolton, about a mile nearer the Fell, he found the wind was gently blowing in an

opposite direction, as it was at Kirkby Thore. This settles a point, that he had long suspected but never proved before, viz. that the current comes down again after its bounce up at the Bar. Street House is about a mile and a half south-south-west from Kirkby Thore.

Mr. Marriott gives a table of the days of Easterly (north to south-east) and *Helm Winds*, 1885-1887.

From this table, he says, it will be seen that the Helm occurs at all seasons of the year; and that it is not such a rare occurrence as was generally supposed to be the case, the Helm Bar having been observed on forty-one occasions in 1885, sixty-three in 1886, and nineteen in 1887.

Mr. Marriott's paper should be read by all interested in local climates, as the phenomena he has so carefully described from his own and other trustworthy observations are calculated to shed much fresh light on the movements of the air in leeward valleys. Local winds should always be studied with a good contour map before us, coloured like the one that illustrates this work, so as to show at a glance the trends of the valley-systems and the elevated lines of the water-partings which flank or enclose them. We should ever remember that one of the chief functions of atmospheric currents, whether general or local, is to scour out and destroy all malarial and residual airs from the beautiful dales and valleys of our country, where they mostly are to be found.

The Rainfall.

In a highly interesting and most valuable paper on "The Origin, Progress, and Present State of our Knowledge of the Rainfall in the Lake District," the eminent meteorologist George James Symons, F.R.S., published in "Symons's British Rainfall" for 1867, gives a most interesting record of work done, and a chronological list of the workers from the earliest period in the history of this most important department of meteorology. With his kind permission I am enabled to

reproduce the tables in his article, and his observations on them. In the first place I shall give his *List of Rain Gauges in the Lake District, and their results.* This list is illustrated by a map constructed by the author.

Station.	Authority.	No. of Years.	Altitude.	Approximate Mean Fall.
			ft.	in.
1. Wastdale Head	Miller.[1]	9	247	100
" " "	Fletcher.[2]	4	"	90
2. Mosedale	"	2	624	80
3. Brant Rigg	Miller.	6	695	85
" " "	Fletcher.	4	"	78
4. Scafell Pike	Miller.	3	3,200	73
" " "	Fletcher.	4	"	63
5. Great End	"	3	2,982	69
6. Esk Hause	"	3	2,550	81
7. Sprinkling Tarn	"	4	1,985	121
8. Styehead Tarn	Miller.	6	1,472	105
" " "	Fletcher.	4	"	119
9. Taylor's Gill	"	1	1,077	174
10. The Stye	Dixon.[3]	7	948	152
" " "	Fletcher.	3	1,077	182
11. Seathwaite	Dixon.	22	422	140
" " (Fletcher's 4 inch)	Mrs. Dixon.	3	"	127
" " (Symons's 8 inch)	"	1	"	130
12. Stonethwaite	Miller.	7	330	108
" "	Fletcher.	4	"	103
13. Watendlath	Symons.[4]	1	867	83
14. Derwent Island	Marshall.[5]	3	240	49
15. Crow Park	"	3	260	55
16. Keswick	Crosthwaite.[6]	22	270	59
17. Greta Bank	Spedding.[7]	2	400	55
18. Skiddaw	Symons.	1	1,677	60
19. Langdale	Miller.	8	250	118
" "	Balme.[8]	1	380	107
20. Wythburn	Lawson.[9]	1	574	88
21. Helvellyn (Birkside)	Symons.	1	1,800	92
22. High Close	Balme.	5	553	77
23. Elter Water	"	1	200	84
24. Longrigg Fell	"	1	1,050	69

[1] Dr. Miller, F.R.S.
[2] I. Fletcher, Esq., F.R.S.
[3] Mr. Dixon.
[4] G. J. Symons, Esq., F.R.S.
[5] H. C. Marshall, Esq.
[6] J. F. Crosthwaite, Esq.
[7] J. J. Spedding, Esq.
[8] E. B. W. Balme, Esq.
[9] Rev. Basil Lawson.

Station.	Authority.	No. of Years.	Altitude.	Approximate Mean Fall.
			ft.	in.
25. Rydal	Jones.[10]	1	185	76
26. Lisketh Howe	Davy.[11]	20	200	78
27. Low Nook	Wilson.[12]	8	170	75
28. Matterdale	Symons.	1	1,400	87
29. Gowbarrow	,,	1	1,100	77
30. Greenside.	,,	—	2,000	Imp.
31. Stang End	Marshall.[13]	1	1,550	80
32. Greenside Mills	Symons.	—	1,000	Imp.
33. Patterdale Hall	Marshall.	7	500	75
34. Kirkstone Pass.	Symons.	1	1,500	88
35. The Howe, Troutbeck . .	Wilson.[14]	22	470	80
36. Halsteads	A. Marshall.[15]	18	480	52
37. Water Millock.	W. Marshall.	8	720	54
38. Sharrow Bay	A. Parkin.[16]	1	500	35
39. Swarth Fell	Symons.	1	1,000	46
40. Mardale Green.	,,	1	800	90
41. Measand Becks	,,	1	1,200	54
42. Wet Sleddale	,,	1	1,500	93
43. Lowther Castle	Parkes.[17]	3	840	44
44. Great Strickland	Plumer.[18]	3	647	38
A. Easdale Tarn	Symons.	1	1,175	97
B. Burrow House	Langton.[19]	1	270	66

Mr. Symons remarks that one of Dr. Miller's principal deductions was, that the amount collected increased with the elevation up to 2,000 ft., and then diminished. Grouping the whole of the returns according to the altitude, we get :—

Below 500 ft.,	16 stations,	mean fall,		87 inches.		
500 to 1,000 ft.,	10	,,	,,	,,	79	,,
1,000 to 1,500 ft.,	10	,,	,,	,,	100	,,
1,500 to 2,000 ft.,	4	,,	,,	,,	92	,,
2,000 to 2,500 ft.,	none.					
2,500 to 2,000 ft.,	2	,,	,,	,,	75	,,
3,500 to 3,500 ft.,	2	,,	,,	,,	68	,,

[10] F. M. T. Jones, Esq.
[11] Dr. Davy, F.R.S.
[12] J. C. Wilson, Esq.
[13] W. Marshall, Esq., M.P.
[14] Admiral Wilson.
[15] A. Marshall, Esq.
[16] A. Parkin, Esq.
[17] J. Parkes, Esq., C.E.
[18] H. H. Plumer, Esq.
[19] S. Z. Langton, Esq.

This would indicate that the maximum occurs at nearer 1,000 ft. than 2,000 ft.; and the same indication results from grouping the stations having 100 inches and upwards, according to their amounts. There are 14 such stations, their mean fall is 128 inches and mean altitude 785 ft. There are 5 stations having more than 128 inches, and their mean altitude is 785 ft.; and there are 9 stations having between 100 inches and 128 inches, and their mean altitude is 782 ft., thus showing how slight is the effect of altitude. Lastly the wettest spot known is 1,077 ft.; the next wettest at 422 ft., and there is only one station above 1,500 ft. which has a fall of even 100 inches.

The slight effect of altitude is evident all through the table, continues Mr. Symons; for instance—Skiddaw (18), is 1,400 ft. above Keswick (17), yet the amount differs only by one inch. Again, Wythburn (20) and Birkside (21) differs by 1,200 ft., and in amount only by 4 inches. Sometimes the amount is largely in excess at the lower station, as with Elterwater (23), at the foot of Loughrigg, and Loughrigg Fell-top (24), a difference of 850 ft., and a deficiency of 15 inches at the greater elevation.

Concerning the distribution of rain in the district the following appear to be indisputable facts:—

1. That there are various spots in the district at which the true mean annual rainfall is above 100 inches.

2. That true mean falls of 125 inches and upwards are at present only known to occur at the head of Borrowdale.

3. That in the greater part of the district the fall is 80 or 90 inches, and that these heavy falls occur almost as far to the east as *Shap*; but that the amount in the north-eastern parts decreases with great rapidity, the clouds having been previously condensed by contact with the mountain tops, until a few miles N.E. of Penrith is probably almost as dry as Bedford.

I may observe that, if we take the records in the above list

that have been made at the first six stations in Wasdale, and compare them with those that have been made at the six stations in Borrowdale, it will be seen that irrespective of altitude, the greater rainfall will be found to be to the leeward of the south-westerly winds, the prevailing wind in these islands. For instance, at the six stations in Wasdale, open to the full afflux of the south-west winds, and having a mean altitude of 1,716 ft. above sea level, the mean rainfall amounted only to 79·8 inches, whereas at the six stations in Borrowdale, on the lee-side, as regards south-westerly winds, and having a mean altitude of only 1,044 ft., the rainfall is 135·8 inches. If the reader will consult the "Contour Map," he will see the dale in which *Wastwater* lies characterized by loops of *dark and light blue*, and *light brown*, pointing towards the great Transverse Ridge or water-parting, and fully open to the unchecked sweep of the south-west winds. If he will now carry his eye in a north-easterly direction, he will see the *dark brown* ridge which indicates a height above the 1,000 contour-line, indented by a loop of *light brown*, succeeded lower down by one of *light blue*; this is *Borrowdale*, where the rainfall is in such excess over Wasdale.

From my own experience in the Isle of Man and Scotland I believe that as a rule more rain falls in the leeward valleys when the winds are from the south-west; and, although I do not ignore the effect of altitude and its cooling condensing effects, I think we do not take sufficiently into account the influence of concussion, entanglement, and the eddying of the currents of air upon the minute particles of instantaneously condensed vapour; for the act is instantaneous and before gravitation has time to bring the nascent raindrops to the ground on the side where the first concussion takes place, they are hurried over the water-parting, and as they cross the ridge, the lower parts of the current lag, and are overtaken by the upper, so that gyration of the mass takes place, in the same way as we see in waves breaking on the

sea coast; entanglement results which favours the more abundant rainfall.

Kendal. Mr. Isaac Fletcher, F.R.S., in "Symons's British Rainfall" for 1865, gives the following facts for the town of Kendal, as recorded by Mr. Samuel Marshall, one of the oldest and most accurate meteorologists of that time, who found that at Kendal the average for forty years, viz., from 1822 to 1862, was 52·271 inches. He also deduced the following results:—

		Inches.
Average of 1st twenty years	...	55·717.
,, ,, 2nd ,, ,,	...	41·825.
,, ,, 1st ten years ...	...	57·+.
,, ,, 2nd ,, ...	...	54·+.
,, ,, 3rd ,, ...	...	50·+.
,, ,, 4th ,, ...	...	47·+.

Mr. William B. Tripp, C.E., F.R. Met. Society, has lately published the following:[1]—

Average Yearly Rainfall.

Period.	KENDAL.	EDINBURGH.	EXETER.	LONDON.	Average.
1831–40. .	55·2	25·4	28·5	23·2	33·1
1841–50. .	52·3	24·3	29·8	24·1	32·6
1851–60. .	45·7	25·4	27·8	25·0	31·0
1861–70. .	51·9	27·0	30·3	23·8	33·2
1871–80. .	51·9	29·4	35·8	26·5	35·9
1881–90. .	48·7	23·8	30·8	23·2	31·6

Mr. Fletcher remarks that in agricultural districts, such as the neighbourhood of Kendal, drainage and improved cultivation of the soil have no doubt been the chief causes of the

[1] *The Times*, January 25th, 1892.

diminution of rain, but these having been comparatively inoperative in the district about *Seathwaite*, no such diminution seems to have taken place. Mr. Fletcher gives the following Table :—

Results of twenty-one years' observations on the rainfall at Seathwaite, viz., from 1845 *to* 1865 :—

		Inches.
Mean of 1st seven years	... ...	143·80.
,, 2nd ,,	... ...	119·85.
,, 3rd ,,	... ...	152·56.
,, 1st fourteen years	... ...	131·83.
,, last ,, ,,	... ...	136·20.
,, the whole twenty-one years	...	138·74.
Maximum, 1861	... ...	182·47.
Minimum, 1855	... ...	88·31.
Maximum in one month, January, 1851	...	28·63.
Maximum in seventy-two hours, December, 3rd, 4th, 5th, 1864...	... ...	15·53.
Maximum in forty-eight hours, December, 4th, and 5th, 1864...	... ...	12·42.
Maximum in twenty-four hours. November, 1846	... ...	6·62.
December, 1864	... ...	6·47.
May 30th, 1865	... ...	6·41.
September, 10th, 1865	...	6·00.

Mr. Fletcher remarks that an inspection of this table gives no indication of a fact which has been observed in other localities, that the average fall is diminishing.

Mr. G. J. Symons, F.R.S., in a highly interesting and important letter published in *The Times*, 18th January, 1892, on "The Rainfall of 1891," gives the rainfall at the little hamlet of Seathwaite, at the head of Borrowdale, as the type :—

County—Cumberland. Station—Seathwaite, Borrowdale.

	Depth of Rain in each Month.	Difference from the Average for the Month.	Total Difference from Average since January 1st, 1891.
	Inches.	Inches.	Inches.
January	11·34	− 0·84	− 0·84
February . . .	2·60	−10·04	−10·88
March	8·35	− 2·15	−13·03
April	7·63	+ 0·49	−12·54
May	5·46	− 3·15	−15·69
June	3·08	− 3·50	−19·19
July	5·82	− 5·17	−24·36
August	26·99	+18·54	− 5·82
September . . .	20·86	+ 9·13	+ 3·31
October	15·92	+ 5·33	+ 8·64
November . . .	13·89	− 0·90	+ 7·74
December . . .	25·25	+10·44	+18·18
Total	147·19		

In "Symons's British Rainfall" for 1868, p. 40, the Editor makes the following interesting remarks with regard to the rainfall in the Lake District. He says the amount of rain at most English stations in 1868 was very near the average. In the north-western, or rather perhaps in the north-north-western districts, it was generally about 10 per cent. above the mean, but in the Eastern Lake District the excess rose to 20, 30, and even 40 per cent., culminating in 42 per cent. at the head of *Ullswater*, and 37 per cent. at the head of *Hawes-Water*. This remarkable irregularity, confined to a small space, and decreasing on an average 10 *per cent. for each three miles* from the points just mentioned, renders it quite impossible to deduce any trustworthy mean values from this year's returns. It is sufficiently singular that within *ten miles* two stations should have, one 11 per cent., the other 42 per cent., above their respective mean values. This phenomenon is not a casual or doubtful one, as the following Table will prove:—

No. on Map.[1]	Stations.	Altitude.	Rainfall in 1868.	Excess in 1868. per cent. of Mean.
		Feet.	Inches.	
35	The Howe	470	82·77	6·4 ?
19	Langdale	380	118·25	10·5
28	Matterdale	1,400	96·50 ?	10·9 ?
16	Keswick	270	65·72	12·3
24	Loughrigg	1,050	78·00	13·0
A	Easedale	1,175	111·00	14·4
42	Wet Sleddale . . .	1,500	108·75 ?	16·9 ?
27	Low Nook	170	88·88	18·5
13	Watendlath	867	99·24	19·6
21	Birkside	1,800	112·50	22·3
17	Greta Bank	400	67·33	22·4
37	Water Millock . . .	720	67·70	25·4
44	Great Strickland . .	647	48·37	27·3
B	Barrow House . . .	270	84·60	28·2
39	Swarthfell	1,000	59·00 ?	28·3 ?
41	Measand Becks . . .	1,200	69·75 ?	29·2 ?
20	Wythburn	574	115·75	31·5
36	Hallsteads	480	69·20	33·1
40	Mardale Green . . .	800	123·08	36·7
33	Patterdale	500	106·14	41·5

In a valuable paper by Mr. Thomas G. Benn, F.R. Met. Society, printed in the *Quarterly Journal* of that Society, January, 1887, on "the Climate of Carlisle," the following facts are recorded with regard to the *Rainfall* of that district.

The mean Annual Rainfall for the 23 years, 1863–1885, was 29·80 inches. The following are the mean annual amounts of rain at several places in the neighbourhood:—

	Inches.
Kirk Andrews	38·16.
Scaleby	33·95.
Wigton	35·80.
Silloth	35·28.
Aspatria	34·55.

[1] Numbers on Mr. Symons' Map in "British Rainfall," 1868.

	Inches.
Maryport	34·13.
Cockermouth	44·24.
Workington	38·58.
Seathwaite	143·21.
Keswick	61·57.
Loweswater	53·83.
Penrith	31·20.
Patterdale	85·86.
Hexham...	34·35.
Newcastle	29·06.
Dumfries	40·10.

The means here given are for the twenty-four years ending with 1883. By far the largest rainfall at Carlisle was that of 1877, viz., 44·63 inches, being more than double the amount for 1867, which was the driest year of the period, the fall being only 22·20 inches.

Dividing the whole into five periods, it was found that for the

			Inches.
3 years,	1863 to 1865,	the mean annual rainfall was	26·34.
5 ,,	1866 to 1870,	,, ,, ,,	25·91.
5 ,,	1871 to 1875,	,, ,, ,,	32·01.
5 ,,	1876 to 1880,	,, ,, ,,	32·31.
5 ,,	1881 to 1885,	,, ,, ,,	31.05.

The period, 1866 to 1870, was therefore the driest, and the five years, 1876–1880, the wettest, and they correspond respectively with the periods of highest and lowest mean temperatures which Mr. Benn has given thus :—

			Inches.
3 years,	1863 to 1865,	the mean temperature was	47·5.
5 ,,	1866 to 1870,	,, ,, ,,	48·2.
5 ,,	1871 to 1875,	,, ,, ,,	47·8.
5 ,,	1876 to 1880,	,, ,, ,,	46·9.
5 ,,	1881 to 1885,	,, ,, ,,	47·1.

The heaviest rainfall for any month was 7·84 inches, in

July, 1884, being 4·66 inches in excess of the mean for the month. This exceedingly wet July was followed by the warmest August of the 23 years. The next wettest month was August, 1877, viz., 7·39 inches. No month was without rain, the driest being January, 1881, a month of intense frost, when 0·30 inches of rain fell, or 2·40 inches below the average for the month; and the next driest was June, 1884, with a fall of 0·36 inches.

The average number of rainy days was 174. The year of greatest rainfall frequency was 1877, when there were 233 wet days, while in 1865 there was only 127.

The mean driest month was April, 1·67 inches, and the wettest was August, when the average rainfall was 3·38 inches. The mean daily amount of rain in April was 0·056 inches, and in August 0·110, being thus double that of April. The amount of rain which fell during the first six months, from January to June, when the temperature was rising, was 12·03 inches; and for the last six months, when the temperature was falling, the mean amount was 17·78 inches.

Mr. Benn has appended two very useful tables to his valuable report, which I subjoin.

Monthly Rainfall at Carlisle:—

Months.	Average Rainfall.	Greatest Rainfall.	Year.	Least Rainfall.	Year.
	Inches.	Inches.		Inches.	
January . . .	2·70	5·84	1884	·30	1881
February . .	1·97	4·08	1869	·60	1873
March . . .	1.70	3·26	1876	·47	1863
April	1.67	3·12	1882	·40	1873
May	1.88	5·09	1865	·94	1883
June	2.11	4·05	1872	·36	1884
July	3.18	7·84	1884	·43	1868
August . . .	3.38	7·39	1877	1·21	1869
September . .	3.13	5·28	1883	·72	1865
October . . .	3.01	5·12	1874	1·27	1866
November . .	2.68	6·04	1877	·48	1867
December . .	2.40	4·76	1868	·83	1870

The next Table gives a statement of the principal meteorological elements for each season, the values in all cases being the means for the 23 years. By "winter" is meant the months of December, January, and February; "spring," March, April, and May; "summer," June, July, August; and "autumn," September, October, November. The observations for December, 1862, are utilised in order to complete the record for the 23 winters.

	Winter.	Spring.	Summer.	Autumn.
Temperature—	°	°	°	°
Mean	38·7	45·6	58·0	47·7
Mean Maximum. . . .	44·1	54·2	67·8	55·2
Mean Minimum	33·1	37·7	49·2	40·5
Mean Daily Range . . .	11·0	16·5	18·6	14·7
Mean Dead Point . . .	35·4	40·6	51·7	42·5
Relative Humidity . . .	88	83	80	85
Mean Amount of Cloud (0–10)	7·6	6·9	7·0	6·9
	Inches.	Inches.	Inches.	Inches.
Rainfall	7·11	5·24	8·67	8·82
No. of Rainy Days . . .	44	37	44	48
Wind, Days, N.	4½	7	3	5
" " N.E.	2½	7	4	4
" " E.	12	17	11	12
" " S.E.	9	6	3	6
" " S.	13½	8	8	12
" " S.W.	13	10	13	11
" " W.	19	23	33	22
" " N.W	6½	6	4	5
" " Calm	10	8	13	14

Winter.—The *warmest* winter was that of 1868–9, when the mean temperature was 43°·3 4°·6 above the average. That winter was warmer than the springs of 1877 and 1883, and nearly as warm as the spring of 1885.

The *coldest* winter occurred in 1878-79. The mean temperature on that occasion being only 30°·5, or 8°·2 below the average. The next mildest winter was that of 1862–63, viz. 41°·9, and the next coldest that of 1880–81, viz: 33°·8.

On comparing the periods as before, it is found that the five years 1866 to 1870 had the mildest winters, viz. 40°·1. This was also the period of the greatest winter rainfall. The four coldest winters (between 1876 and 1880) had a mean temperature of 37°·4. The average mean temperature for the first 13 years was 1°·0 higher than that for the last 10 years.

The *wettest* winter was that of 1876–77, but it was nearly equalled by that of 1868–69, the *rainfall* in each case being respectively 12·14 ins., and 11·29 ins. In the former case there were 64 and in the latter 59 rainy days.

The winter of *least* rainfall was that of 1878–79, which was also the coldest, the amount being only 3·90 ins., and there were only 22 wet days, 14 of which occurred in February. The wettest and driest winter has rainfalls respectively 5·03 ins. *above*, and 3·21 ins. below the mark.

Spring.—The *warmest* spring was that of 1868, the mean temperature being 48°·5, or 2°·9 *above* the average; and the *coldest* occurred in 1877, the mean temperature being 42°·9, and it was colder than the winter of 1868–69. The difference between the warmest and coldest springs was 5°·6. The next *warmest* spring was that of 1871, viz. 47°·5, and the next *coldest* that of 1883, viz. 43°·0.

The four consecutive years 1871–75 had the highest mean spring temperature, viz. 46°·6, while for the five years 1876–80 the mean temperature was 44°·8, that being the coldest period. These were respectively the periods of least and greatest mean *spring* rainfalls.

The mean *spring* temperature for the 13 years 1863 to 1875 was 1°·3 higher than for the 10 years 1876 to 1885.

The *wettest* spring occurred in 1868 and was followed by the warmest summer of the whole period. The rainfall was 8·6 ins., which fell on 42 days.

The *driest* spring was that of 1875, when there was a total rainfall of only 3·00 ins. on 34 days.

These amounts were respectively 2·82 ins. *above* and 2·24 ins. *below* the average.

The mean spring rainfalls for the last 10 years had increased by 0·68 ins. compared with the first 13 years.

Summer.—The *warmest* summer occurred in 1868, which year had also the *wettest* spring. The mean temperature of the summer of that year was 60°·5 or 2°·5 above the average. The *coldest* summer was that of 1881, the mean temperature being only 55°·0 or 3°·0 below the average. The next *warmest* and *coldest* summers were respectively those of 1878 and 1864, whose mean temperatures were 59°·8 and 55°·2. Of the five-year periods, that from 1866 to 1870 had the *warmest* summers, viz. 58°·7, and the period 1881 to 1885 the coldest, viz. 57°·1. The mean summer temperatures for the first 13 years and the last 10 years were nearly identical, the last, named period showing a fall of 0°·1.

The summer of greatest rainfall was that of 1877, and this fall was much heavier than that of any winter, spring, or autumn during the 23 years. The amount was 15·04 ins., which fell on 62 out of the 92 days, and that exceedingly wet summer followed the *coldest* spring, and preceded one of the wettest autumns, included in the whole period. The *driest* summer occurred in 1869, the amount being only 3·66 ins. on 29 days—less than one-fourth the amount for 1877. These extremes of rainfall were respectively 6·37 ins. *above*, and 5·01 ins. *below* the summer averages.

The mean summer rainfall for the last 10 years was 2·68 ins. more than the mean for the first 13 years.

Autumn.—The *warmest* autumn was that of 1865, viz. 49°8. The autumns of 1880 and 1885 were the *coldest*, the mean temperature in each case being 46°·0. These values are respectively 2°·1 *above*, and 1°·7 *below* the mean, and the difference between the *warmest* and *coldest* autumns was 3°·8. The next warmest autumn occurred in 1866, and the next coldest in 1873, the means being 49°·0 and 46°·3.

Dividing into three and five year periods, as before, we find a continuous decrease in autumn temperatures from 1863 to 1880. The mean for the past three years was 48°·5, falling continuously to 47°·1 for the years 1876–80. The last 5 years show some recovery, the average being 47°·8. The first 13 years showed a mean autumn temperature 0°·6 higher than the last 10 years.

The *wettest* autumn occurred in 1874, when there were 12·78 ins. of rain on 62 days. The next *wettest* was 1883 and 1877, in which years there were respectively 12·54 ins. and 12·29 ins. The *driest* autumn was that of 1867, when there were only 4·69 ins. on 39 days, and next to it in point of dryness, was 1879 with 5·27 ins. on 35 days. The amounts for the *driest* and *wettest* autumns were respectively 4·13 ins. *below*, and 3·96 ins. *above* the average. The mean rainfall for the last 10 autumns was less than that for the first 13 by 0·20 ins.

Mr. Benn concludes his remarkably able paper thus:—

" The general result of the foregoing investigations points to the fact that, comparing the 13 years 1863 to 1875, with the 10 years 1876 to 1885, the *mean annual temperature* has *decreased* 0°·9, while concurrently with this, the average yearly *rainfall* has *increased* by 3·33 ins. With respect to the seasons, the *mean temperature* of *winter* and *spring* is decidedly *lower* in the latter period, and so in a less degree is that of *summer* and *autumn* also; while in the matter of *rainfall, the summer* has been decidedly *wetter*, *winter* and *spring* a little *wetter*, and *autumn* a little *drier* in the last 10 years. Speaking generally, those *summers* which have been more than usually *cold* have been accompanied by a *large quantity* of rain, while in *winter* the conditions are reversed, and *warmth* and *wet* generally go together.

As introductory to the following important tables Mr. Symons remarks that as years roll on, and the laws of the distribution of rain are gradually developed, the fallacy

of practices of the wisest of our precursors is rendered evident to all. Without quoting such preposterous cases as that of tabulating the fall in *one* year as the mean rainfall of the place of observation, in which case an error of 50 per cent. may occur, many have thought that five or six years would give a pretty fair mean, especially if two or three stations were taken together. The following tables show that the six years, 1853 to 1858, were 20 per cent. below the average of 22 years, and that five years, 1859–1863, were nearly 20 per cent. above it. Thus we have two periods of six and five years respectively, in one of which the fall is half as large again as in the other. Thus it becomes obvious that the mean fall can be ascertained only by two methods: either by long continued observations at the place, or by reference to some proximate long-established gauge. This is the only method by which the observations made in the Lake District can be reduced to their true values.

Most fortunately, Mr. G. J. Symons observes, the registers of *The Howe, Troutbeck*, at *Seathwaite*, and at *Keswick*, extend from the first year of Dr. Miller's work to the present time; they have therefore been employed as standards of all the gauges, Dr. Miller's, Mr. Fletcher's, and his own.

Mr. Symons then gives a specimen of the mode by which the approximate means have been obtained.

The rainfall at Wastdale Head was as follows :—

	Inches.	
1845	108·55.	Mean of these 9 years, 103·67.
1846	105·93.	
1847	96·34.	
1848	115·32.	
1849	107·22.	
1850	108·76.	
1851	97·94.	
1852	109·58.	
1853	83·39.	

Determination of the ratio of the Rainfall as of 22 *years to the mean of the whole period* 1845 *to* 1866.

IN THE LAKE DISTRICT.

Year.	Rainfall in each year.			Ratio at each Station.			Mean Ratio.
	The Howe, Troutbeck, Windermere.	Seathwaite, Borrowdale.	Keswick.	The Howe, Troutbeck.	Seathwaite, Borrowdale.	Keswick.	
	Inches.	Inches.	Inches.				
1845	76·30	151·87	62·20	96	108	106	103
1846	77·71	143·51	67·68	97	103	116	105
1847	78 00	129·24	58·28	98	92	100	97
1848	91·34	160·89	66·41	114	115	113	114
1849	75·42	125·47	48·80	94	90	83	89
1850	79·81	143·96	59 53	100	103	102	102
1851	80·77	139·60	62·34	101	100	106	102
1852	115·62	156·74	79·97	145	112	137	131
1853	65·97	113 69	50·45	83	81	86	83
1854	65·95	143·48	46·82	83	103	80	89
1855	47·54	88·31	37·40	60	63	64	62
1856	55·28	105·52	47·55	69	75	81	75
1857	55·30	116·60	48·88	69	83	84	79
1858	60·07	114·61	50·27	75	82	86	81
1859	94·95	147·29	66·89	119	105	114	113
1860	102·58	142·20	54·17	129	102	93	108
1861	116·26	182·58	74·42	146	130	127	134
1862	94·27	170·03	61·37	118	121	105	115
1863	84·97	173·84	71·54	106	124	122	117
1864	75·74	134·67	52.68	95	84	90	90
1865	64·05	117·49	49·18	80	96	84	87
1866	98·69	179·12	70·81	124	128	121	124
Mean.	79·85	140·03	58·53	100	100	100	100
1867	77·83	133·31	52·14	97	95	89	94

By reference to the last column of the ratio table it will be found that the mean ratio of these nine years was 102·9 inches; that is to say, the rainfall in those years was 3 per cent. above the average. It only remains, therefore, to divide the mean observed fall by the mean ratio to deduce the approximate true mean, *e.g.* 103·57 ÷ 102·9 = 100 inches.

In reference to the irregularities given above in the rain-

fall for 1868 in certain parts of the western and eastern Lake Districts, Mr. Symons observes that it seems hopeless to detect the cause of the irregularities by discussing the yearly totals; we must examine the monthly falls, and see if they throw any light on the subject. The only satisfactory mode of doing this is by computing for each station the percentage of the total yearly fall, registered in each month of 1868. Few observers are aware how strict a check this process is upon the accuracy and regularity of their observations. As illustrating at once the facility of this mode of checking the regularity of the distribution of rain even in this irregular tract of country, and the peculiarities of the past season, we print the resultant percentages in detail. Prefixed to the table is a column (for which Mr. Symons acknowledges his indebtedness to Mr. Guster's paper in *British Rainfall*, 1867, p. 35), giving the percentage of the yearly total which ordinarily falls in the Lake District, and at the end is another giving the averages in 1868. See table, p. 261.

Mr. Frederick Guster, F.R. Met. Soc., to whose elaborate and philosophical paper in *British Rainfall*, 1867, Mr. Symons refers *on an investigation of the monthly percentage of the mean annual rainfall at stations situated in the British Islands* (p. 33), draws attention to the important fact, that not only does the mean annual rainfall vary considerably at different parts of the British Isles, but taking the average of a considerable number of years, the portion of the annual rainfall which occurs in each month varies considerably at different stations. As an example, take the records from a few stations at which rainfall was registered continuously during the decennial period 1850 to 1859; and in choosing them, we will select those in which the mean annual measurement varied considerably. Thus we have Leeds (Philosophical Hall), where the mean fall was 21·140 inches; Norwich, where it was 26·085 inches; Exeter (St. Thomas), with a mean of 31·154 inches; Kendal (Westmorland), 44·912

Month.	Ordinary Percentage.	Patterdale.	Mardale.	Hallsteads.	Wythburn.	Measand-beck.	Swarth Fell.	Barrow House.	Gt. Strick-land.	Water Millock.	Greta Bank.	Birkside.	Watend-lath.	Low Nook.	Wet Sleddale.	Easedale.	Loughrigg.	Keswick.	Matendale.	Langdale.	The Howe.	Mean percentage in 1868.
Jan. .	14	11	14	14	13	11	16	14	14	9	15	13	14	11	13	12	10	15	14	10	8	12·6
Feb. .	9	13	11	13	11	11	7	11	8	13	9	10	11	11	12	12	8	11	11	12	14	11·0
March	6	13	12	9	13	11	11	13	11	11	13	13	13	12	12	15	11	12	12	17	15	12·4
April	6	6	6	9	6	7	8	6	7	7	6	6	6	6	6	5	6	6	8	7	5	6·5
May .	4	5	5	3	4	3	5	4	4	5	5	4	4	4	4	4	4	4	4	4	3	4·1
June .	6	1	3	0	2	2	1	2	1	1	2	2	2	1	2	2	2	2	2	2	1	1·6
July .	7	0	1	2	0	0	0	1	1	1	0	1	1	1	2	1	1	1	1	1	1	·9
Aug. .	9	9	9	10	10	13	10?	9	9	9	11	8	10	11	9	11	11	11	9?	9	9	9·9
Sept. .	7	5	4	6	4	5	8	3	6	6	5	4	4	4	4	3	4	5	6	3	4	4·6
Oct. .	10	10	12	9	11	12	8	12	9	9	10	11	12	13	15	12	15	8	8	12	13	11·1
Nov. .	9	7	5	9	6	5	4	6	7	7	5	7	5	7	7	5	6	4	4	5	8	6·0
Dec. .	13	20	18	16	20	20	22	19	22	21	19	21	18	19	13	18	22	22	20	18	19	19·3

inches; and the Howe, 72·128. We see that at these places the mean annual amounts vary considerably, so that the rainfall at the highest is upwards of three times as great as that at the lowest. Now, if we compare the mean *monthly* values during the same time, we find that they vary too, but do not bear the same proportion to each other as the annual totals do. To make this clear, Mr. Guster gives the following table, in which he represents the monthly values by their percentage of the total annual fall. See table, p. 261.

Mr. Symons further observes that we may probably safely assume it to be proved that the abnormal excess is not connected with the ordinary relative wetness of the stations, nor with their altitude. Let us then try if it is due to the geographical position. Reference to the map will at once show that, with few exceptions, the stations on the outskirts had about 12 per cent. more than their average, and those in the centre 30 or 40. If the district be divided into squares of twenty-five miles area each, the result is—

12	17	11	29	27
10	28	42	33	...
10	13	16	...	17

Similar results are obtained if the squares are drawn with their sides S.W. and N.E., instead of S.—N.; and still more markedly by describing circles of $2\frac{1}{2}$, 5, $7\frac{1}{2}$, and 10 miles radius round a point two miles north of Brotherswater, the actual values are,—

			Mean.
Under $2\frac{1}{2}$ miles	... 42	... ...	42
Over $2\frac{1}{2}$ and under 5	... 37, 33, 29, 28, 25, 22	...	29
Over 5 and under $7\frac{1}{2}$	... 32, 19, 14, 11 ? ...	...	19
Over $7\frac{1}{2}$ and under 10	... 28, 22, 20, 17 ? 11, 6	...	17
Over 10 and under $12\frac{1}{2}$	27, 12, 10	... ...	16

Mr. Symons gives another table (p. 263) of the percentage of the total yearly rainfall registered in each month

Stations.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual Fall.
Leeds . . .	7·6	4·3	5·6	8·1	7·3	11·0	10·4	11·4	10·0	10·7	8·3	3·3	21·140
Norwich . .	7·5	5·6	4·4	6·9	7·3	6·8	11·9	10·6	9·5	11·3	11·6	6·6	26·085
Exeter. . .	9·8	6·2	6·7	8·6	7·1	7·5	7·1	6·7	7·8	12·1	9·6	10·8	31·154
Kendal . .	12·1	8·6	5·6	5·3	4·9	8·3	8·2	10·6	7·8	9·4	8·2	11·0	44·912
The Howe .	15·0	9·9	5·8	5·6	4·0	6·2	6·8	8·7	7·1	9·7	8·7	12·5	72·128
Coniston . .	13·2	9·2	6·2	5·5	4·1	6·6	6·7	9·4	7·3	9·9	9·1	12·8	71·400
Wray Castle	13·9	9·1	5·8	5·5	4·3	6·4	7·4	9·1	7·0	10·2	8·7	12·6	60·807

of 1868, compared with the ordinary monthly percentage of rainfall in the Lake District, and thus comments upon it: From this table we learn (1) that the only months in which

the fall differed much from the average were March and December in excess, and June and July in defect; (2) that except in January and September the distribution over the district was singularly uniform. This disposes of one probable explanation of the excess in the central districts; viz. an excessive rainfall during some one month. There is nothing to support such a view, and this latter appears to drive us to the conclusion, that whatever was the cause of the excess, it acted almost equally throughout the year. Therefore, unless we are prepared to condemn the mean values given last year (1867), which for several reasons we think it would be unwise and almost impossible to do, we are driven to the conclusion that *the causes which ordinarily produce the excessive rains in the Lake District operated to an unusual extent during the year* 1868 *at the heads of Ullswater and Haweswater.*

If it be assumed that the heavy rainfall of the Lake District is produced by the cooling of the air by contact with the colder mountains, it does not seem improbable that in so warm a year as 1868, the difference between the temperature of the air and that of the mountain masses would be greater than usual, and therefore the condensation would be proportionately greater, especially at stations situated like Patterdale and Mardale.

The returns of the western Lake District support as strongly as it is possible so to do, the conclusions arrived at above; but, Mr. Symons adds, they do not throw the slightest glimmer of additional light on the cause. The following observations were supplied by Mr. Fletcher (*British Rainfall*, 1868, p. 44) See table, p. 265.

From this table we see, as in the eastern, so in the western, district, the excess does not vary with the altitude nor with the amount, but small as is the area occupied by these stations (five miles from west to east, and three from north to south), they yet indicate the same fact as previously

No. on Map.[1]	Station.	Altitude.	Rainfall in 1868.	Excess in 1868 per cent. of mean.
		Feet.	Inches.	
9	Taylor's Gill	1,077	178·17	2·5
3	Brant Rigg	695	80·78	3·7
7	Sprinkling Tarn	1,985	126·81	4·8
1	Wastdale Head	247	95·38	6·0
11	Seathwaite, 4 in. . . .	422	138·33	9·1
11	Seathwaite, 8 in. . . .	422	142·50	9·6
5	Great End	2,982	75·63	9·6
8	Stye Head	1,472	130·71	9·8
11	Seathwaite Old, 5 in. . .	422	157·11	12·2
4	Scawfell	3,200	70·77	12·3
6	Esk Hause	2,550	92·08	13·7
10	The Stye	1,077	207·49	14·1
12	Stonethwaite	330	119·49	16·0

obtained from the larger area, the western stations having a mean excess of 8 per cent., and the eastern ones of 11 per cent., which agrees perfectly with the amount due to the district by the concentric circular arrangement round Brotherswater before mentioned.

	Mean Excess. Eastern stations. Per cent.		Western stations. Per cent.
Within a radius of $2\frac{1}{2}$ miles ...	42	...	—
Over $2\frac{1}{2}$ and under 5 miles ...	29	...	—
Over 5 and under $7\frac{1}{2}$ miles ...	19	...	—
Over $7\frac{1}{2}$ and under 10 miles ...	17	...	—
Over 10 and under $12\frac{1}{2}$ miles ...	16	...	16
Over $12\frac{1}{2}$ and under 15 miles ...	—	...	10
Over 15 and under $17\frac{1}{2}$ miles ...	—	...	8

Mr. Symons winds up his most admirable and instructive paper by remarking that the above table abundantly corrobo-

[1] These figures can be transferred to a tracing of "the Contour Map," and the rainfall then studied in connection with the configuration of the land. It would however be necessary to obtain records of the wind-direction during the months, weeks, or days selected for investigation.

rates the facts previously deduced. Though the explanation may be doubtful the facts are not.

I have already given *in extenso* (pp. 259, 261) the two tables referred to in the above extracts from *British Rainfall*, 1867 and 1868, as they are most valuable to the meteorologist; the numbers refer to those on Mr. Symons's maps of the Lake District, on which are marked the exact position of all the rain gauges. Those who would study the rainfall of any district should always do so with a good outspoken contour map before them, and a register of the wind direction. The "Contour Map" described in Chapter VI. is intended to facilitate studies in meteorology; for unless we study the meteorology and the physical configuration of a district together, we shall go a very little way towards solving the difficult problems often involved in the phenomena of local climates and their influence on health and disease.

Sunshine.

This all-important factor in climate, and the source of all that makes life worth living for, has been the least studied of all the subjects connected with meteorology and climatology. Up to within a very late period there have been no satisfactory methods of measuring the duration of sun-light. In 1857, Mr. J. F. Campbell of Islay, F.G.S., drew the attention of the Royal Meteorological Society to a method of registering solar action by its efforts in charring organic substances, such as wood, cloth, or paper. Mr. Campbell just used an ordinary engraver's globe filled with acidulated water: this method was succeeded by a solid glass ball. Mr. Scott, in his paper "On the Measurement of Sunshine,"[1] thus describes Mr. Campbell's instrument for measuring the duration of sunshine. Mr. Campbell placed his ball inside a bowl of mahogany, and thus obtained a six months' record; this

[1] R. H. Scott, M.A., F.R.S., *Quart. Journal of the Royal Meteorological Society*. Vol. xi., No. 55, July, 1885.

instrument was at first fixed on the roof of the General Board of Health in Parliament Street, and the register commenced with the winter solstice of 1854. After the winter solstice of 1857 a glass ball was substituted for the original engraver's globe. Several improvements were made in the instrument to secure a daily record, and these resulted in Prof. Stokes's Sunshine Recorder, which was completed in 1879, and first issued to the meteorological stations in 1880.

Whilst investigating the effect of aspect on the wheat-yield of the British Isles, I began to realise the importance of those principles laid down by Hippocrates, in his "Airs, Waters, and Places," in which work are described the different kinds of local climates that are to be expected according to aspect, and the diseases that are affected or caused by them. The risings and the settings of the sun were the points used in determining and describing the several aspects. For instance, a city exposed to warm winds, as those that blow from between the points of the winter rising and winter settings of the sun, would be sheltered from the north; on the other hand, those cities which are sheltered from the southerly winds and are open to those blowing between the rising and setting of the summer sun, would be exposed to the northerly winds. The author then describes the nature of the aspects that face the sky between the risings of the summer and winter sun; and lastly those aspects which face the west: all are carefully discussed in their relation to sunshine, winds, and diseases.

It is strange to think how little we have advanced since then in our knowledge of the effects of sunshine and prevailing winds upon the soil. The English farmer I found ignoring aspect as a rule, while the Scotchman made it his special study; coincident with this personal experience, I find the following facts in the Agricultural Produce Statistics of Great Britain for 1890. The estimated ordinary average wheat-yield in bushels per acre is stated (p. 13) to be 21·45 bushels per acre in the rich and *fertile* county of *Devon* (Lat. N. 50°);

whilst in that of Edinburgh (Lat. N. 55°) it amounts to 36·71 bushels per acre: the latest returns for 1890 states that a total yield in *Devonshire* on 83,440 acres, amounted to 1,689,581 bushels of wheat, 20·25 bushels per acre; and that in the same harvest, 176,154 bushels was yielded in the county of Edinburgh by 4,249 acres; which is equal to 41·46 bushels per acre in the northern county, six degrees further north than Devonshire. We shall find in the sequel that, where the land is open to the wind and the sun, there *wheat* will produce the heaviest yield, and malarial diseases of the rheumatic type fail to swell the mortality from heart disease and the circulatory organs.

The relation of aspect and sunlight to health and disease among all organised beings was readily acknowledged by the father of medicine; but our daily experience proves that the principles laid down as the result of vast experience are ignored, not only by the agriculturist, but by those who have enjoyed a higher culture.

The maps which illustrated my lectures on the Geographical Distribution of the Wheat-yield, showed the following facts, or rather the dawning of facts; for at that time the observations had been few and not always continuous: and even now the materials are so scanty that they can only be used as rough illustrations.

1. That *low foreshores* (such as those in the Cumbrian area), especially those facing the south-west sea-winds, facilitated the free passage of the moisture-laden currents inland, and enabled them to retain their transparence even when near the point of saturation, so long as the low level of the ground over which they passed did not rise beyond certain limits. This can be illustrated by the *contour map*.

Suppose the moisture-laden currents approaching the Cumbrian coast line to be so saturated with vapour of water, that a reduction in their temperature of one degree Fahrenheit would condense the hitherto invisible vapour, and form cloud.

Let us further suppose that the *dark blue area* between the coast line and the 250 feet contour line, at the time of those almost saturated currents passing over it, to be of sufficient temperature as not to cause the vapour to condense into cloud, the air would remain transparent and the sun's rays make their mark on the Sunshine Recorder.

These transparent currents, however, in the course of time cross the 250 contour line and into the *light blue* inter-contour space, between that level and the 500 feet contour; and whilst doing so would have their temperature reduced; and being almost saturated with water, cloud would form, and the sun's rays would cease to be recorded, We may calculate that there is a loss of one degree Fahrenheit for every 300 feet of ascent. Under the above circumstances the sun's rays might be enjoyed all over the *dark blue* area, whilst a cloud-mist might be hanging over the *light blue* areas, obscuring the higher grounds from our view.

2. But elevated foreshores, characterised by precipitous cliffs, obstruct the free passage of the sea winds inland, and suddenly throw them up into the higher and colder regions of the air, where their vapour at once passes from its transparent and sun-transmitting state, to a condensed, cloudy, and sun-obscuring one, and in this form is carried over the area to the leeward.

3. That very elevated ridges, extending 1,500 feet, such for instance as the backbone of Scotland, the transverse ridge of the Lake District, the Pennine Chain, and other well-known heights, partially exhaust the moisture of the air-currents from the sea, which creeping upon them in their course inland, by condensing it into rain or snow; so that when continuing their course upwards over the ridge, into the leeward area, their air is so dry as no longer to condense on losing temperature, so that they pass over the country to the leeward as transparent and sun-transmitting currents. This is well seen in the difference between the sunshine records,

during winter, and the prevalence of westerly and south-westerly winds, of the eastern and western watersheds of the backbone of Scotland.

Instead of giving the results in detail of the maps referred to above, it will be sufficient just to indicate the principal features of sunshine distribution in Great Britain and Ireland.

Taking the mean annual percentage of possible sunshine in the British Isles, the South-West of England (35·5 per cent.), South of Wales and South of Ireland (33·2), recorded the highest; then came the East of England (32·2), South-East of England (31·3), and the East of Scotland (31·8); these divisions were coloured in shades of *red*, whilst those below the mean were coloured blue: thus the North-East of England recorded 29·3 per cent.; Midland Counties, 29·8; North Ireland, 29·5; West of Scotland, 29·1; North of Ireland, 29·5; and the West of Scotland, 22·1.

With regard to the Cumbrian area it will be seen that it suffers, in common with the British Isles, generally from scarcity of observations; but if those collected are studied in connection with the configuration of the country by means of the contour map, several questions will find solution, which the simple records at first sight do not seem capable of answering.

According to the original observations extending over 1880–1883, the mean percentage of possible sunshine during the four seasons in the north-western and eastern divisions of England were as follows:—

	North-Western (including Cumbria). Per cent.		Eastern. Per cent.
Spring	38·26	...	37·50
Summer	34·50	...	32·90
Autumn	26·30	...	27·40
Winter	16·36	...	18·26

We must bear in mind that between these two divisions the

Great Pennine Chain or northern part of the backbone of England (the *crimson line*) lies; and the fact that during the prevalence of the south-westerly winds in late autumn and winter, cloud formation and rain precipitation take place on the windward side of the elevated land; and that the air currents, as they continue their onward journey over the leeward country, carry with them reduced resources for cloud making; so that during these seasons there is comparatively *less* rainfall and *more* sunshine on the eastern than on the western side of the great water-parting of England. As regards *sunshine*, the above figures bear out this well established fact; the percentage of sunshine on the east being for autumn 27·40, and winter 18·26; and 26·30, and 16·36 respectively on the west.

If we take the following three stations, the *Isle of Man*, *Silloth* and *Durham*, and compare their sunshine records for the three years 1881–1883 inclusive, we shall find the following:—

Season.	Isle of Man. Per cent.	Silloth. Per cent.	Durham. Per cent.
Spring	43·4	39·7	37·6
Summer	38·6	34·3	34·1
Autumn	30·4	28·0	26·3
Winter	22·0	17·1	21·2

Here again we see that Durham, lying in the lee of the great water-parting, as regards the south-westerly winds during the winter months, has a higher percentage of sunshine than Silloth, with all its advantages of nearness to the sea and a low foreshore.

In *spring* there is a mean daily possible duration of 13 hours 43 minutes and 5 seconds; in *summer*, 15 hours and 20 minutes; in *autumn*, 10 hours 40 minutes and 4 seconds; and in *winter*, 8 hours 46 minutes; whilst the mean *annual* duration is 12 hours 6 minutes and 40 seconds.

SUNSHINE RECORDS AT SILLOTH.

No. of Hours.	Jan. H.	Feb. H.	Mar. H.	Apr. H.	May. H.	June. H.	July. H.	Aug. H.	Sep. H.	Oct. H.	Nov. H.	Dec. H.
1880	—	—	—	—	201	196	143	191	127	103	70	23
1881	53	58	101	169	264	171	132	138	105	113	39	39
1882	21	41	96	147	282	205	197	170	130	66	54	27
1883	46	65	140	150	218	184	174	138	116	112	73	27
1884	20	48	74	130	181	171	160	177	143	73	57	24
1885	27	51	115	—	—	—	—	—	—	—	—	—
Percentage of Possible Duration of Bright Sunshine.	%	%	%	%	%	%	%	%	%	%	%	%
1880	—	—	—	—	40	39	29	42	34	32	29	11
1881	22	22	28	41	53	34	26	30	28	35	16	18
1882	9	16	27	35	56	41	39	37	35	20	22	12
1883	19	25	39	36	44	37	35	30	31	35	30	12
1884	8	17	21	31	36	34	32	39	39	23	23	11
1885	11	19	32	—	—	—	—	—	—	—	—	—

Sunshine observations are on the increase: in the Cumbrian area there have been added two fresh stations, the records of which during 1890 and 1891, when placed side by side, may be of interest to the reader.

	Bowness-on-Windermere.				Keswick.				
	1890.		1891.		1890.		1891.		1891.
	H.	M.	H.	M.	H.	M.	H.	M.	No. of Days.
January	48	45	72	25	—		66	20	21
February	92	00	86	20	102	5	128	15	22
March	97	20	112	10	96	15	119	40	29
April	167	15	126	5	175	20	178	0	27
May	200	45	208	15	224	30	206	40	31
June	145	45	261	50	135	40	277	15	30
July	166	50	183	0	155	35	196	45	29
August	148	50	118	55	165	20	149	15	29
September	147	20	138	10	143	35	163	5	25
October	65	45	129	55	83	30	150	30	31
November	67	10	71	10	52	55	73	0	24
December	54	45	58	50	46	45	54	0	21
	1,401	45	1,567	5	1,381	30	1,762	45	319

For the above observations I am indebted to the proprietor of the Bowness-on-Windermere Hydropathic establishment, and Mr. Thomas Paulin, of the Beeches, Keswick. When we consider how the amount of our inland sunshine is dependent on the configuration of our coast-line at all times, but especially during those months when the range between the readings of the wet and dry bulb thermometers is not great, every particular with regard to aspect, height above sea-level, character of foreshore, whether it is abrupt and obstructive, or sloping and wind-favouring, should be given in describing the station and its surroundings. When once the reader has studied the distribution of certain diseases, and the yield of crops, such as wheat, in connection with the physical geography, he will never forget the lessons he has been taught, and will then realize the value of studying sunshine in relation to the atmospheric currents, and the configuration of the land, especially the foreshores and sea-cliffs.

Sunshine Recorders.—The study of medical geography having opened up such a wide field for research since 1868, when the remarkable facts connected with the Geographical Distribution of Heart Disease, Rheumatism, Cancer and Phthisis were first demonstrated; and as these facts are intimately associated at their sources with the soil, its vegetation, and the sun's rays, any improvement in these meteorological instruments that will tend to promote their more general use by lessening their price and increasing their usefulness and greater adaptability to our requirements, cannot fail to command our interest.

Hitherto Sunshine Recorders have been used by very few meteorologists on account of their costliness; and naturally these would be placed in the best positions to catch every ray of sun: especially when they form a part of the meteorological equipment of stations at what are called health-resorts.

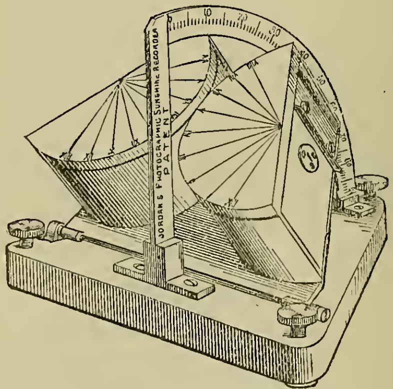
In future investigations in the valleys, where Heart Disease

and Malarial Rheumatism are rife; where high mortality from Cancer is coincident with flooded areas, decomposing and decomposed vegetable and animal matters, and microphytic life; where Goître, Ague, Jungle and other fevers have their habitats, will have to be made on the spot, and the different factors engaged in the work of disease-nests will have to be gauged as to their share in the genesis of such diseases.

The sun's rays command our first thought in all such inquiries, and will have to be studied in connection with the culture of those minute organisms that we have termed *pathogens*, and the chemical changes in soil and air.

On these grounds I was glad to find that Mr. James B. Jordan had invented a photographic Sunshine Recorder which promises not only to enable observers to multiply the sunshine recording stations, but to secure greater accuracy on account of the greater sensitiveness of the chart.

The action of the Jordan Sunshine Recorder differs entirely from that of Campbell's, the record being obtained by means of photography instead of by the burning power of the sun.



THE JORDAN PHOTOGRAPHIC SUNSHINE RECORDER.

The instrument figured above consists of two semi-cylindrical dark chambers, in each of which is placed a prepared chart, one for the morning and the other for the afternoon

record. The rays of sunlight being admitted into these chambers through small apertures in the sides, are registered on the sensitized paper or chart, and travelling over it by reason of the earth's rotation, leave a distinct trace of chemical action, thereby recording duration of sunshine and relative degree of intensity. The cylinders are mounted on a triangular plate, which is hinged to a suitable stand, with a means of adjustment, to admit of the instrument being used in any latitude.

The charts are printed on sensitized paper ruled with vertical lines indicating the hours and minutes of the day. They are supplied with the instruments by the makers ready for use.[1]

Mr. Jordan and his colleague, Mr. W. Topley, F.G.S., some years ago published a geological map[2] of the South-East of England in relief, which is of the greatest service to the medical geographer in studying the effects of local climates, of land configuration and geological structures, on disease. This map will be fully described in Part II. of this work, including the Thames Basin. We are all acquainted with Mr. Jordan's Glycerine Barometer, the corrected readings of which are daily published in *The Times*.

Mean Temperature, Isotherms, etc.

In 1871 Dr. Alexander Buchan, F.R.S.E., published a valuable report on the Temperature of the British Isles; and again in 1880 the same distinguished meteorologist published another report on an average of twenty-four years in the journal of the Scottish Meteorological Society. These reports are accompanied by maps showing the arrangement of the *isotherms* for each month of the year throughout the British Isles, and provide us with the following facts :—

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[1] Negretti and Zambra, London.

[2] Stanford, London.

January Isotherms.—Across the geological map are drawn two *blue* lines, marked at their extremities with figures denoting the degrees of equal temperature which their courses represent: thus the "*January Isotherm*, 40°," crosses the corner of the map from N.W. to S.E., closely approaching the land off the Bootle District; and after crossing Duddon Mouth takes, a course parallel to Walney Island. The other "*January Isotherm*, 39°," crosses from Scotland through Solway Firth, then enters Wigton District, and crosses successively, at first in a north-easterly and then in a southerly direction, Penrith, Ullswater, and the district of Kendal.

The 39° January isotherm has been used at a line of section in describing the geology of the area (p. 164).

July Isotherms.—On the *Contour Map* the isotherms of 60° and 61°, the former of which can be traced from Scotland over the Solway Firth, across Cockermouth, over the great Transverse Ridge, in the Scafell mountain mass (I.), across its south-eastern ridge (p. 114), along the valley of Coniston Water and finally into Morecambe Bay. The July isotherm, 61°, only just loops round the south-eastern corner of East Ward District.

The student in tracing these isotherms will be struck by the interesting fact that whilst the more *coastal*, 40° isotherm is the higher of the two in winter (January); the most *inland*, 61°, is the higher in the summer (July).

If we trace these isotherms first over the British Isles, and then beyond them, we shall gain an enlarged view of their significance in relation not only to home but foreign areas.

The January isotherm, 40°, stretches from the Outer Hebrides (N. Uist), through Islay, Mull of Cantyre, off the coast of Cumberland, as described, through North and South Wales, across the Bristol Channel and the South-East, along the Hampshire and Sussex coast, towards the Straits of Dover, where it loops round to the S.W. on the north coast of France. The first loop up towards the Hebrides, and the

second up the English Channel, are both due to the high temperature of the sea caused by the Gulf Stream. The lower degree, 39°, has a more inland course; before entering the map it has traversed the Orkneys, the Hebrides, the South-West of Scotland, and on leaving Westmorland, pursues an irregular course through the centre of England, and after reaching Gloucestershire, crosses the Severn, and afterwards the Thames, the right bank of which it follows until it reaches the North Foreland; so that these winter isotherms link the Lake District with widely different parts of Great Britain, the common cause of which is to be found far off in the Atlantic, over which if we further trace the course of the 39° and 40°, we shall obtain a better insight into the reason how it is that the Gulf Stream has such a powerful influence, not only on the temperature of the British Isles, but of the western part of the continent of Europe. For instance, after the 40° January isotherm has been carried to the Shetlands (60° N. Lat.), it is seen crossing to the west and forming a loop pointing to N.E., after which it pursues a south-westerly course to the south of New York (35° N. Lat.), or more than 20° of latitude further south; the ascent to high, and the descent to low latitudes, being coincident with the trend of the warm Gulf Stream in a north-easterly direction, and that of the cold Labrador Current to the south-east respectively. If we now take the other limit of the isothermal loop of 40° we can trace it through England, France, across Northern Italy, the Adriatic Sea, to the north of Greece, and thence along the south coast of the Black Sea, and across the Caspian Sea, where it will be found on the latitudinal horizon of the south of New York, to which point we have just traced the western limit. This description may be aided by reference to a chart of the world, or the January isotherm 40°, actually traced on the map illustrating Dr. Alexander Buchan's article on Meteorology in the "Encyclopædia Britannica," p. 135 (ninth edition). To the sea then we must ascribe the high winter

temperature of our area and the British Isles, and now it will be seen that to the land we are indebted for summer temperature as expressed by the *July isotherms.*

The July isotherms, 60° and 61°, belong to a series of concentric lines which surround a circular area, excluding London and portions of Middlesex and Essex to the north and east of the metropolis; this limited area is surrounded by a circular isotherm 64°, within which a mean July temperature is recorded amounting to 64°. The July isotherm 64° is next surrounded by the 63·0°, which is encompassed by the 62°, outside of which comes the 61°, which is seen looping in a *north-westerly* district upwards at the corner of the *Contour Map.* It will be remembered that the loops produced by the Gulf Stream had a north-easterly direction; succeeding this isotherm is the one for the mean July temperature of 60°, the course of which has already been described; so far as this area is concerned it will be seen that the north-westerly direction of the loop is preserved.

Now if we follow the 60° line it will be seen that immediately it leaves the land it is no longer looped up towards the north-east, but at once depressed towards the south-west, where it enters North America in the latitude of the Gulf of St. Lawrence (50°) and Newfoundland—the Labrador Channel cold stream still exercising its deflecting powers, although not so pronouncedly as in winter. On the other hand it will be observed, on examining the chart of isothermals in the work referred to, that instead of being depressed towards the south of Europe as the January isotherm has just been seen to be, the summer isotherm, after crossing the North Sea, travels in a north-easterly direction through Norway and the north of the European continent, almost parallel to the line of 65° north latitude, or on the same line where the January isotherm of 40° was turned back to the south-west.

The Isotherms which cross the Cumbrian area arranged according to months, and tabulated with the monthly mean air-temperature and the temperature of the sea.

Month.	Isotherms.	Monthly Means.	Sea Temperature.		
			Isle of Man.	Solway.	Morecambe.
January	39°–40°	37°2	44°	41°	39°
February	41°–40°	38°9	43°	42°	38°
March	43°–42°	40°2	43°	42°	41°
April	47° [1]	45°2	45°	45°	43°
May	52°–51°	49°8	48°	49°	50°
June	57°–58°	56°0	53°	57°	56°
July	60°–61°	58°5	57°	60°	61°
August	60°	58°0	59°	60°	62°
September	56°	54°0	59°	57°	60°
October	50°–49°	47°7	55°	53°	56°
November	43°–42°	40°3	50°	47°	48°
December	41°–40°	38°0	46°	43°	43°
Year	49°		50°2	49°6	49°7

Sea-Temperature.—The observations from which these data have been derived are published in the Meteorological Atlas of the Meteorological Council. They have been principally those taken during the three years, July 1879 to June 1882, at certain coastguard stations, light-houses and lightships; for instance, the Bahama Bank Light-Vessel, off Ramsey, supplied the data under the heading Isle of Man; the Solway Light-Vessel, that for the Solway Firth; and one of the coastguard stations the observations under Morecambe Bay.

The Isle of Man has no large rivers emptying themselves into the Irish Sea, such as would affect the temperature of the sea-water at a distance of ten miles from the land as the Bahama Light-Vessel is from the mouth of the river Sulby at Ramsey; the observations then taken from this station

[1] The Meteorological Atlas has 48°.

may give us approximately the mean sea-temperature during the several months in the year.

The waters at the other stations in Solway Firth, and Morecambe, are essentially estuarial, and are influenced by the rivers that flow into them; for instance, the *Solway Firth* receives the waters of the rivers Eden, Derwent and others, that have their origin on the *northern* flanks of the great Transverse Ridge; whilst *Morecambe Bay* receives the Kent, the Leven, the Esk and Duddon, all of which have their sources on the sunny side of the Transverse Ridge: we should then expect that, during the six summer months of the year, from May to October inclusive, the Morecambe Bay water would be hotter than the sea itself; and that during the more snowy and darker six months, that Solway Firth would be colder than the sea, owing to the melting of the snow and the comparative absence of the sun on the northern flanks of the great Transverse Ridge. The mean temperature of the sea for the six months including May and October amounted to 55°·1, whilst for the same period Morecambe Bay registered 57°·5, and Solway Firth 56°·0, or 2°·4 and 0°·9 higher respectively. During the remaining six months including November and April, the main sea temperature amounted to 45°·1, whilst the waters in Solway Firth were only 43°·3, and those of Morecambe Bay 42°·2, or 1°·8 and 2°·9 colder respectively. It appears therefore that the southern flanks of the great Transverse Ridge get more than their share of heat during the sunny six months, by which the waters of the rivers that take their rise on them are warmed; for the same sun which warms during May to October, from November to April also melts the snow and keeps the rivers well supplied with ice-cold water; and on comparing the temperature of the Solway Firth with that of Morecambe Bay it will be seen that they differ too; for whilst the waters in the latter are *warmer* in the summer, they are also *colder* in the winter six months; this is coincident with the fact

that on an aspect where the greatest advantage of sun heat is enjoyed during summer, there is the greatest amount of snow melted during the winter. It must be remembered, however, that on the windward side of the Transverse Ridge condensation takes place and rain falls before the air currents have passed over the ridge in winter, and that the broad sands of both the Solway Firth and Morecambe Bay, when exposed at low water, accumulate a great amount of heat during sunshine.

Local Mean Temperatures, according to the tables contained in Dr. Alexander Buchan's paper on "The Mean Temperatures of the British Isles." [1]

The following are the stations at which the observations were made, the means of which are recorded in the subjoined table.

Scaleby, Cumberland, is in the south of the Registration District of *Longtown*, about a mile from the point where the three Registration Districts of Carlisle, Brampton, and Longtown meet; the parishes representing at this point these districts are Crosby-upon-Eden, Irthington, and Scaleby respectively. The height of the station above the sea is 111 feet, and therefore lies within the *dark blue* area on the *Contour Map*.

Silloth is another station not named on the maps; its site may be found by tracing the coast line north of the point where the January isotherm 39° crosses it, until a projecting part of the line is reached in the parish of Holme St. Cuthbert; to the east of this point Silloth lies within the *dark blue area*. The other stations will be easily recognised on the maps.

[1] *Journal of the Scottish Meteorological Society*, New Series, June, 1880, p. 36.

Stations.	Counties.	No. of Years.	Years Specified.	Latitude N.	Longitude W.	Height above Sea.
				°	°	Feet.
Scaleby	Cumberland	3	1879–81	54° 58′	2° 52′	111
Carlisle	,,	20	1861–80	54° 53′	2° 55′	114
Silloth	,,	24	1857–80	54° 52′	3° 22′	28
Alston	,,	2	1880–81	54° 49′	2° 25′	1,145
Cockermouth . . .	,,	19	1862–80	54° 39′	3° 23′	146
Barrow-in-Furness [1]	Lancashire	2	1880–82	54° 7′	3° 11′	60

Table of Mean Monthly Temperature.

Months and Seasons.	Scaleby.	Carlisle.	Silloth.	Alston.	Cockermouth.	Barrow-in-Furness.
	°	°	°	°	°	°
December . .	38·5	38·4	39·4	34·1	39·7	41·0
January . .	37·2	37·8	38·7	33·3	39·0	39·6
February . .	39·0	39·7	40·4	35·3	40·2	40·2
Winter . .	38·2	38·6	39·5	34·2	39·6	40·2
March . . .	40·2	41·0	41·7	36·8	41·6	42·0
April . . .	44·9	46·5	46·4	41·6	46·9	47·2
May . . .	49·8	51·0	51·0	46·4	51·2	51·5
Spring . .	44·9	46·1	46·3	41·6	46·5	46·9
June . . .	56·2	57·2	56·9	52·6	57·3	57·5
July . . .	58·1	59·5	59·5	55·5	59·9	59·8
August . . .	57·6	58·8	59·3	54·7	59·6	60·0
Summer . .	57·3	58·5	58·5	54·2	58·9	59.1
September . .	54·3	54·8	55·3	50·5	55·5	56·2
October . .	48·0	48·1	49·1	43·9	49·7	50·3
November . .	40·3	40·5	41·9	36·8	42·2	43·0
Autumn . .	47·5	47·8	48·4	43·7	49·1	49·8
The Year . .	47·0	47·6	48·3	43·3	48·5	49·0

[1] This station is in the extreme south-west of the Ulverston Registration District, to the east of and opposite to Walney Island.

Local Mean Atmospheric Pressure.

Before giving in a tabular form the results of observations made in this area, it will be well briefly to refer to what Dr. Alexander Buchan has written with regard to the distribution of atmospheric pressure in the northern hemisphere.

Mean Atmospheric Pressure in January.

In this month, when the influence of the sun on the northern hemisphere falls to the minimum, the *greatest* pressures are massed over the continents of that hemisphere, and the *least* pressures over the northern parts of the Atlantic and Pacific Oceans, over the Antarctic Ocean and southern hemisphere generally.

In the northern hemisphere pressure rises in Central Asia to upwards of 30·5 inches. In the north of the Atlantic a *low* mean pressure obtains over a narrow belt stretching from Iceland to the south of Greenland, the normal pressure being in Iceland 29·38, and in Greenland 29·36 inches. Again to the south-west of Spain and Portugal is a high-pressure area stretching to the south-west from Longitude 4° W. to 45° W., between Latitude N. 40° and 25°; this area is characterized by a pressure in January equal to 30·2 inches, so that we may expect the pressure over the British Isles to decrease from south to north, as they lie between the *high* pressure in the Atlantic to the south-west of the Spanish Peninsula, and the low pressure between Greenland and Iceland.

Mean Atmospheric Pressure in July.

In this month the physical conditions are the reverse of what obtains in January; the effects of the influence of the sun on the temperature and humidity of the atmosphere rising to the maximum in the northern and falling to the maximum in the southern hemisphere.

Table of the Isobars that cross the Cumbrian Area during each Month.

Month.	Inches. South.	Inches. North.	Month.	Inches. South.	Inches. North.
January . .	29·86	29·84	July . . .	29·92	
February . .	29·90	29·88	August . .	29·90	29·88
March . .	29·86	29·84	September .	29·88	29·86
April . . .	29·92		October . .	29·84	29·82
May . . .	29·96		November .	29·88	
June . . .	29·96	29·94	December .	29·88	29·86

The Year—29·90 and 29·88 inches.

Table of Mean Monthly Pressure.

Months.	Scaleby.	Carlisle.	Silloth.	Cocker-mouth.	Barrow-in-Furness.
	Inches.	Inches.	Inches.	Inches.	Inches.
January	29·828	29·833	29·823	29·828	29·856
February	29·870	29·880	29·869	29·874	29·894
March	29·840	29·845	29·826	29·833	29·854
April	29·916	29·908	29·900	29·896	29·911
May	29·960	29·951	29·940	29·945	29·952
June	29·946	29·939	29·936	29·937	29·944
July	29·917	29·911	29·906	29·910	29·914
August	29·881	29·877	29·878	29·881	29·896
September . . .	29·875	29·868	29·864	29·865	29·884
October	29·827	29·823	29·814	29·816	29·836
November	29·863	29·860	29·866	29·863	29·875
December	29·856	29·858	29·843	29·850	29·863
The Year	29·881	29·875	29·872	29·875	29·890

Dr. Alexander Buchan, in his concluding remarks on the Isobars of the British Isles, observes that in every month the *Isobars* are deflected more or less from straight lines, the deflections in each case being readily traced to the respective influences, varying with the seasons, of the land and water of the region comprising the British Islands on the distribution of the pressure.

The influence of this *land* is to *lower* the pressure in the *warmer* months, and to *increase* it in the *colder* months of the year, just as takes place on a large scale over the continents of the globe during the summer and winter months. In all seasons, on the other hand, the influence of the *ocean* is to *lower* the pressure, and this depressing influence is much greater near the coasts of the Atlantic than those of the North Sea. Owing, however, to the Mediterranean character of the *Irish Sea*, the deflections of the Isobars, as they cross it, stand out as the most striking feature of the curves, showing in an impressive manner some of the more prominent causes which regulate the geographical distribution of atmospheric pressure.[1]

[1] Op. cit. p. 12.

CHAPTER X.

Distribution of Disease.

Section I. The Diseases selected—The Geographical Distribution of Cancer—History of Investigation, 1868—Series of papers in *The Lancet*, 1888—Infrequency of Cancer in the Lake District, 1890—Paper at Congress of Hygiene, 1890—Clays and Limestones—The Defective Supplement of the Present Registrar-General—Dr. Farr's Supplements 1851–60 and 1861–70—Death-rates—Death-rates (female) at different Age-periods—Influence of Sex in Disease—Dr. W. Roger Williams—General Table of New Growths—Table showing the organs principally affected by Cancer, and relative frequency in—Percentage of cases of Mammary and Uterine Cancer—Geographical Distribution of Cancer among Females—Description of the Maps—Index of Colours, and scales of Death-rates—Map I. "All ages"—Map II. "At and above 35 years"—Cancer in the Registration Districts—Groups of *Low* Mortality—Group of *High* Mortality—Great Transverse Ridge—Death-rates in Cumberland, Westmorland, and part of Lancashire—Distribution of Cancer among *Males*—Table of Death-rates from Cancer at different Age-periods, Males and Females—Low Mortality Group—Scale of Death-rates for the two sexes—High Mortality Group (Males)—Male Death-rates in Wigton—Crescentic form of Low Mortality Group—Physical Facts in Low Mortality Group—Limestone—High Mortality Group—Glacial Clay—Valley Systems—Eden and Derwent Floods—Summary of Coincident Diseases and Physical Facts—Mixed Populations—An Epitome of Disease-facts during the 30 years 1851–1880—Cancer as a Cause of Death irrespective of Sex—Table showing Mean Death-rates during the three Decennial Periods, 1851–60, 1861–70, and 1871–80—Remarks on Table—The same coincident facts not confined to the Cumbrian and Lake Area—Extracts from a recent paper on the Influence of Clays and Limestones on the Medical Geography of Cancer.

The Diseases Selected.

THE history of the investigation so far as regards the reasons for selecting Heart Disease, Cancer and Phthisis as illustrations of Disease Distribution in the

British Islands, has already been given in the former part of this work, and it now only remains for me to give the additional trustworthy disease-facts that have been published since the issue of the first edition in 1875.

The Geographical Distribution of Cancer.

The facts connected with the Geographical Distribution of Cancer, among females in England and Wales, at all ages, for the ten years 1851–1860, were first published more than twenty-two years ago in an abstract of my first paper on this subject read before the Medical Society of London, on the 30th November, 1868.[1]

In this paper I first drew attention to the fact that Cancer among females was infrequent in that part of the north-west of England which included the Lake District, and that coincident with the disease-fact was the geological one that this area was characterized by some of the oldest formations, namely the Silurian and Carboniferous, and, physically, included the highest and best drained mountainous districts in the country. In the same abstract I also pointed out the local facts coincident with the higher mortality from Cancer in the Vale of Eden.

In 1875 the full text of my paper read before the Medical Society in 1868 was first published and illustrated by three coloured maps—two small ones of the *Divisions* and *Counties*, which have been reproduced in this edition, and one large map containing the 630 districts into which England and Wales are divided for registration purposes, on a scale of twelve miles to one inch. From the copper plate of this map those that illustrate this chapter have been printed and coloured in accordance with the added facts gathered during the decenniad 1861–1870.

[1] Abstracts of two papers on the Geography of Disease. I. *Heart Disease and Dropsy*; II. *Cancer*. London: Richard Kimpton, 1869.

The broad facts that I first brought before the medical profession in 1868 may be briefly stated.

1. That the districts which had the *lowest* mortality (coloured dark red on the maps) among females from Cancer, were characterized geologically by the older (Palæozoic), and most elevated rocks, such as the *Lower* and *Upper Silurian*, and the Carboniferous *Limestone* series; by the secondary (Mesozoic) *Limestones* of the *Oolite* and chalk formations. These *low* mortality districts were also found to contain the *sources* and upper tributaries of rivers, and *were not subject to floods.*

2. That those districts which had the *highest* mortality from Cancer among females, were on the other hand characterized geologically by *clays*, such as those of the Lias, the *Kimeridge* and *Oxford* of the Oolite, the *Wealdean Clay*, the *Gault*, of the chalk formation, the *London Clay* of the Eocene, the *Boulder Clay* of the Pleistocene or Glacial Period, and the *Brick Earths* and *alluvial* deposits of recent age.

These *high* mortality districts were found to be traversed by *fully formed rivers* that seasonally flooded their banks.[1]

In 1888, at a time when Cancer was much discussed in consequence of the disease having attacked the Crown Prince Frederick of Germany, at the request of the proprietors of *The Lancet*, I wrote a series of articles, which were published in that Journal, on "*The Geographical Distribution of Cancerous Diseases in the British Isles.*"[2] In these papers I discussed briefly what had obtained within the twenty years 1851–1870 in the Lake District as regards this disease.

Again I published in the same Journal, in 1889,[3] a paper devoted to my latest investigations on "*The Infrequency of Cancer among Females in the English Lake District*," and it is my intention to incorporate in the following pages many of

[1] First edition, pp. 63–91.
[2] *The Lancet*, Vol. i., 1888, pp. 314, 365, 412, and 465.
[3] *The Lancet*, Vol ii., 1889, pp. 534–537.

the facts and observations contained in that and former articles.

In August, 1890, I published a letter in *The Lancet* on "*The Increase of Cancer: its probable cause*,"[1] to which I shall have also to refer.

At the late Congress of Hygiene having been requested to furnish a paper in what was then termed the "*Demographical Division*," I read one "*On the Influence of Clays and Limestones on Medical Geography; illustrated by the Geographical Distribution of Cancer among Females in England and Wales*."[2] I took occasion in this paper to draw attention to the amazing fact that the present Registrar-General in his supplement for 1871–1880 had entirely ignored the sexes and had mixed them up together in such a manner as to render the whole of the costly volume useless, not only for scientific purposes, but for the very purpose on account of which so much of the public money had been expended in carrying out; namely, keeping the sexes separate in the Districts of England and Wales, as regards their numbers and their ages, in the Census returns, in order that, in the Supplementary Reports of the Registrar-General, the further facts connected with sex and age should be given in connection with the several causes of death registered.

The sources of the disease-facts dealt with in this work have been the decennial reports, 1851–1860 and 1861–1870, of the late Dr. William Farr, C.B., F.R.S., published by the late Registrar-General, Major George Graham, which were models of accuracy and arrangement, and an honour to the department of Vital Statistics of the English General Register Office. These reports contain the number of deaths that occurred during each of the above decennial periods, from 24 different causes, in each of the 630 registration districts into

[1] *The Lancet*, Vol. ii., 1890, pp. 316–318.

[2] London: John Bale & Sons, 1891, and at W. H. Smith & Son.

which England and Wales are divided, among *males* and *females separately*, living at different age-periods; thus affording a classified mass of disease-facts that cannot be equalled throughout the civilised world. Had Dr. Farr lived, we should have had, ere this, thirty instead of twenty years; however, the splendid work he left behind him as a legacy to science, makes it possible to construct those "Sanitary Maps" which, in the very first letter he wrote to the Registrar-General in 1839, he foretold and hoped would be the outcome of the accumulated facts under the Registration Act. On his leaving the General Register Office, it was naturally supposed that his reports would be models for those of his successor; but the present Registrar-General has shown himself perfectly incapable of even imitating the excellent examples set him, although, with one or two exceptions, he is surrounded by the same staff of officials who helped Dr. Farr in his admirable Tables. He has chosen to depart from the rules laid down by the great master of Vital Statistics, and instead of keeping the males and females distinct in the district tables, he has mixed them together, under the hermaphrodite form of "*persons*," so that it is impossible, for the decennial period 1871–1880, to know how many males or how many females died in any one of the districts from any one of the 24 causes of death. The question, therefore, what was the death-rate among females from *childbirth*, *cancer*, *diseases of urinary organs*, etc., etc., in any of these districts during the above ten years? cannot be answered, either by reference to this defective report, or any other document that has issued from the General Register Office since the appointments of Major Graham's and Dr. Farr's successors; hence it is that instead of thirty years' facts, we have to content ourselves with those of the twenty years, 1851–1870, fortunately preserved for us in the classical reports of the ever-to-be-lamented William Farr.

It must be remembered that the deaths of *males* and *females*

that had occurred during the greater part of 1871–80, had been arranged under Dr. Farr's superintendence in view of a third supplement, in which the sexes would have been kept separate, as in the two former.

From the moment of taking the census in 1871, the greatest care had been taken to keep the enumerated males and females separate, involving a large amount of time and a great expenditure of money; but all this care, time and money was thrown to the winds when the sexes were again mixed in inextricable confusion in the Henniker-Ogle Supplement for 1871-80. The blame for this extraordinary waste of all that made the statistics at the General Register office valuable to science has been thrown upon another department in the following paragraph.

"The main portion of this volume has been drawn up in almost the same form as that adopted in the two previous decennial supplements (Dr. Farr's). The figures, however, in the district tables (pp. 1–370) now relate to *persons*, and are not given, as was previously the case, for *males* and *females separately*. This change has been made not merely to economise *space*, but to give a broader and therefore more secure basis for the calculation of rates, and also in order to meet the practical requirements of the Medical Department of the Local Government Board" (p. iii.).

From this we are led to conclude that in the registration districts the female populations are not large enough of themselves to afford an adequate basis for the calculation of death-rates among the female, and therefore require to be helped out with the male population; for instance, in the case of the deaths from *childbirth* given in the defective Supplement, 1871–81, as estimated by the mean number of males and females mixed up together under the heading "*persons*," we find the annual death-rate for Carlisle during that decenniad to be 1·02 to every 10,000 "*persons*" living. The death rates from *childbirth* in the same district during the decenniads

1851–60 and 1861–70 were 3·46 and 3·53 respectively to every 10,000 *females* living. Dr. Farr, as every other statistician would have done, calculated the rate on a *female* population, not on a jumble of males and females under the head "persons," as the present Registrar-General has done. The mean female population (1871–80) of Carlisle, 25,997, seemingly was not sufficient on which to calculate the death rate from "*childbirth*," so in order "to give a broader and therefore more secure basis for the calculation of rates," 23,697 males were added to the females, when the deaths of women in *childbirth* were estimated for the district of Carlisle; and this manipulation, we are told by the Superintendent of Statistics at the General District Office, is "to meet the practical requirements of the Medical Department of the Local Government Board." Had a thousand or two soldiers, or four or five hundred "navvies" been billeted in Carlisle on the two census nights, how much "broader and therefore more secure" would the Registrar-General's basis for calculation of rates have been, according to his views, which, fortunately for science, are not entertained by any statistician outside the present Registrar-General's office.

If the mobilizable male elements, soldiers and navvies, in the population were not present in the Carlisle district during the above period, there were many other districts in England where they prevailed on the nights of the censuses, and assisted in the defective Supplement to dilute the death-rates from *Childbirth*, *Cancer*, *disease of Urinary Organs*, etc. among females, to vitiate the returns collected by Dr. Farr at the cost of much labour and money, and to destroy the prestige that statistical science in England had deservedly earned in the time of Dr. Farr.

The Disease Facts.

Before proceeding further it will be well to state briefly what are the disease facts which the two coloured *Maps of the Geographical Distribution of Cancer* (Females) display.

In the first place it has been considered desirable, in discussing the medical geography of this important class of diseases, to give as many map illustrations as possible. At p. 15 a brief description of the distribution of Cancer in the eleven Registration Divisions, into which the counties of England and Wales are grouped, was given; and again at p. 37, "Cancer in the Counties" according to its distribution during 1851-60, was described. Two coloured maps reproduced from the first edition of this work illustrate these two first steps in the investigation, and will be found between pp. 14 and 15; whilst at p. 37 extracts from the same edition were given with regard to the Geographical Distribution of Cancer among Females in the 630 Registration Districts of England and Wales. This was the third step, and, so far as the first edition of this work was concerned, the last step in the inquiry up to 1875.

In the present edition, the more fully to illustrate the subject the author has added (i.) two more maps of the distribution of Cancer among females: (ii.) he has added the death-rates from this cause at "*all ages*," as they occurred in 1861–70, to those of 1851–60, so that the distribution of Cancer in the registration districts of Cumberland, Westmorland, and the English Lake District, now extends over *twenty* instead of only *ten* years (1851-70).

2. Again, taking into consideration the fact that during those twenty years a much larger proportion of deaths from this cause occurred among females than among males, it has been deemed advisable to continue the original map, and strengthen it by the additional data afforded by Dr. William Farr's second Supplement (1861-70). The difference between the male and female death-rates from Cancer throughout England and Wales being as follows :—

"*At all Ages.*"	*Males.*	*Females.*
1851-1860	1·94	4·33
1861-1870	2·44	5·23
1851-1870	2·20	4.81

to every 10,000 living.

3. The well known fact that this class of malignant diseases does not show itself markedly fatal until about 35 years of age in women, the author has introduced a map, showing the Geographical Distribution of Cancer among Females, at and above 35 years of age.

The following table, which gives the death-rates among females at certain age-periods for the 20 years, 1851–1870, to every 10,000 females living in England, will make the above statement evident.

Under 25 years	0·16	Annually to every 10,000 females living.
Between 25 and 35 years ...	1·52	
,, 35 and 45 ,, ...	6·34	
,, 45 and 55 ,, ...	14·17	
,, 55 and 65 ,, ...	20·92	
,, 65 and 75 ,, ...	25·96	
,, 75 and above ...	25·95	

Besides the above reasons for illustrating Cancer distribution by means of data derived from death-rates amongst females, is still another of the greatest importance and interest, viz. the fact that the *uterus* and *mammæ* are especially prone to be attacked by this class of disease. On this subject there are no official statistics, but the following table, copied by the kind permission of the author of the elaborate and valuable paper on *The Influence of Sex in Disease*, Dr. W. Roger Williams, F.R.C.S., late Surgical Registrar to the Middlesex Hospital is appended.[1]

[1] *The Influence of Sex in Disease*, by W. Roger Williams, F.R.C.S., late

Dr. Roger Williams has not only dealt with the Registrar-General's returns for the 25 years, 1848–72, when they were under the supervision of Dr. Farr, but in further elucidation of his subject he has compiled tables, which he believes constitute the first attempt to deal with the subject in its entirety. The Hospital Returns refer to in-patients under treatment at the *Middlesex Hospital* during the years 1877–1882, and at *St. Bartholomew's Hospital* during the years 1878–1883. Of these 37,689 were surgical cases—21,350 males, and 16,339 females; 22,995 were medical cases—11,159 males, and 11,836 females. By Table I. it will be seen that of the total number of cases of *Carcinoma*, 16 per cent. were *males*, and 84 per cent. *females;* and by Table II., showing locality and relative frequency of *Cancer*, out of the 5,978 cases, 2,096 were males, and 3,882 females; or 30·06 and 64·94 per cent. respectively.

Table I.—General. All New Growths. (Neoplasms.)

Kind of New Growth.	Total No. of Cases.	Males.	Females.	% Approximate.	
				Males.	Females.
Carcinoma [1].	4,027	641	3,386	16	84
Epithelioma [1]	1,842	1,398	444	76	24
Rodent Ulcer	109	57	52	52	48
Sarcoma	912	477	435	52	48
All other New Growths.	4,210	1,114	3,096		
	11,100	3,687	1,413	33	67

Registrar to the Middlesex Hospital, and Surgeon to the General Western Dispensary. London, J. & A. Churchill, 1885.

[1] In using the terms, *Carcinoma* and *Epithelioma*, Dr. Roger Williams has followed the classification adopted by the Registrars of the Hospitals, whose reports he employed. But in this respect they are not perfectly unanimous, especially with regard to Uterine Cancer.

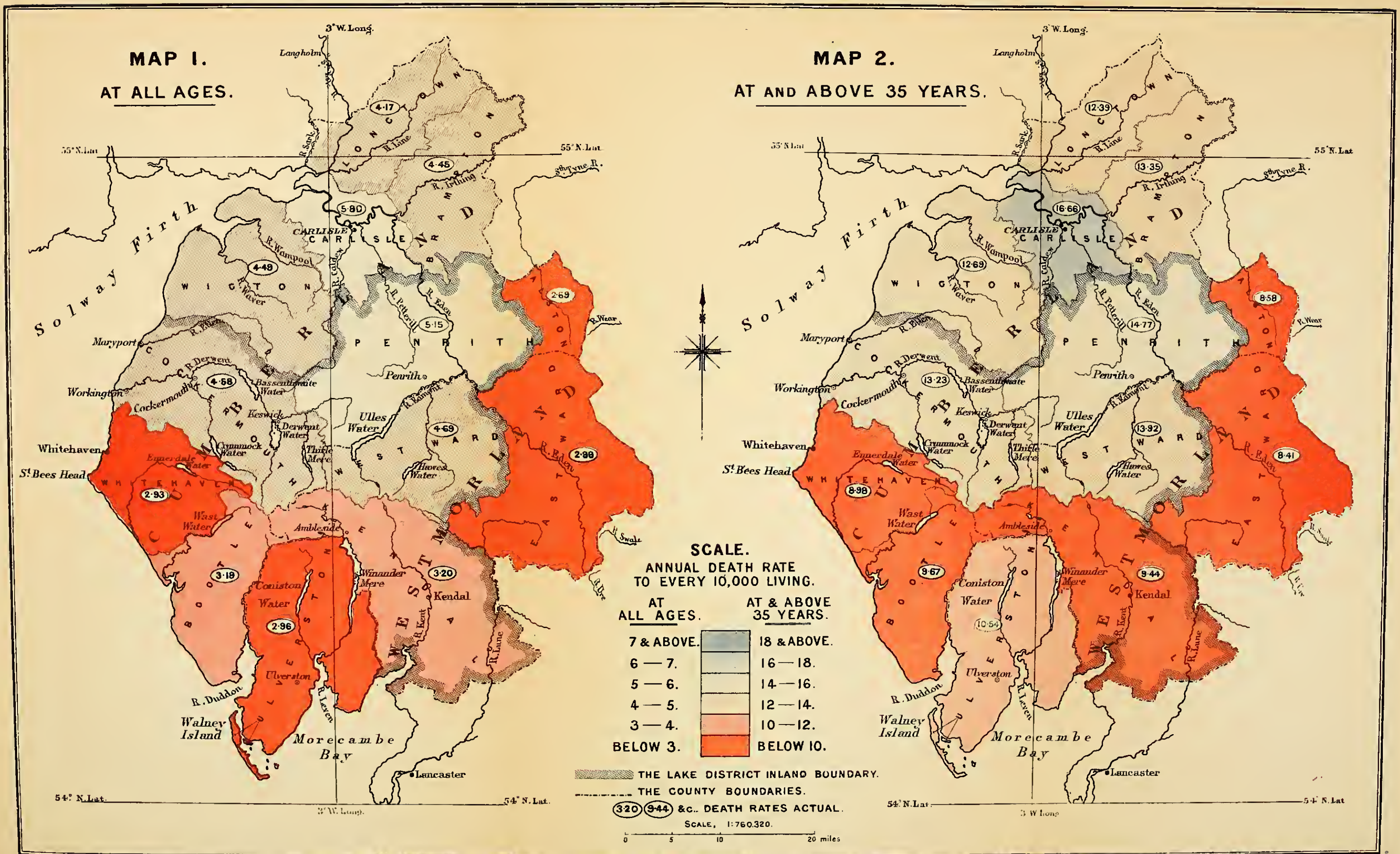
Table II.—Cancer. Showing Locality and Relative Frequency.

Seat of Cancer.	Males.	Females.	Total.
Breast	14	1419	1433
Uterus and Prostate	5	1221	1226
Tongue	419	70	489
Skin	273	143	416
Rectum	136	137	273
Lip	247	2	249
External Genitals	136	107	243
Stomach	150	89	239
Liver	88	84	172
Œsophagus	99	25	124
Mouth	94	13	107
Intestines	25	30	55
Lymphatic Glands	31	24	55
Testis and Ovary	25	21	46
Bladder	30	11	41
Superior Maxilla	22	18	40
Peritoneum	13	22	35
Larynx	22	2	24
Anus	14	7	21
Kidney	13	7	20
Bones (other than Jaws) . . .	7	7	14
Pelvis	1	9	10
Lung	7	3	10
Tonsil	6	3	9
Mediastinum	6	3	9
Pancreas	6	3	9
Pharynx	4	4	8
Inferior Maxilla	6	1	7
Bile Duct	1	2	3
Thyroid	2	1	3
Gall Bladder	1	1	2
Pericardium	1	1	2
Parotid	2	—	2
Pleura	—	2	2
Dura Mater	—	1	1
Lachrymal Sac	—	1	1
Abdominal Wall (not skin) . .	1	—	1
Symphysis Pubis	—	1	1
Urethra	1	—	1
Eyeball	—	1	1
Spleen	1	—	1
Coccygeal Gland	1	—	1
Unclassified	186	386	572
	2096	3882	5978
Per Cent.	35·06	64·94	100·00

NCER (FEMALES),

MAPS OF THE GEOGRAPHICAL DISTRIBUTION OF CANCER (FEMALES),
IN THE ENGLISH LAKE DISTRICT,
CUMBERLAND AND WESTMORLAND,
1851——1870.

BY ALFRED HAVILAND, M.R.C.S.E., &c.



SWAN SONNENSCHEIN & Co. LONDON.

Maclure & Co. Lith. to the Queen London

By this table it will be seen that among *females* the following percentages obtain—

Breast...	36·55 per cent.
Uterus	31·45 ,,
Other Organs...	32·00 ,,
	100·00

So that the essentially *female organs of reproduction* suffer from *Cancer* to the extent of 68·00 per cent., whilst all the organs possessed more or less in common with males, are only subject to this disease to the extent of 32·00 per cent. These valuable Tables have been given in the hope that they may induce Registrars of Hospitals to publish similar statements, which would be made still more valuable by the addition of the names of the *civil parishes or townships* where the cases have resided previously to the development of the disease.

The Geographical Distribution of Cancer in the Registration Districts in the Cumbrian, Westmorland and Lake District.

Females.—As this sex has been abundantly shown to bear the brunt of the attacks by this class of malignant disease, it will be well to take its distribution among females first.

Description of the Maps.—If the reader have followed me through the description of the Contour and Geological Maps, those illustrating Cancer and other diseases will be easily understood; and all that is now required will be a brief explanation of the coloured scale. Map I. is devoted to the geographical distribution of Cancer among females "at all ages," and Map II. to the distribution among women "at and above 35 years" of age.

The death-rate scale naturally differs, the figures being lower on the "*all ages*" side than on Map II. or "*at and above 35 years*" side; thus—the colours selected for indicating the different death-rates above and below the death-rate from

this and other causes throughout England and Wales are *red* (vermilion) and *blue* (French blue); the death-rates *above* the average are coloured *blue* in three shades; the *darkest blue* (+ + +) indicating the *highest* mortality; and the *darkest red*, the *lowest* (− − −): between the extremes the colours shade off towards the centre of the scale or average-point. As these colours and their shades cannot be introduced into the letter-press or described without taking up much space, the following *plus* and *minus* signs will be used to indicate them:—

Scale.

Annual death-rate *to every* 10,000 *females living.*

At all ages.		*At and above 35 years.*
7 and above	Darkest Blue + + +	18 and above
6 to 7	Darker Blue + +	16 to 18
5 to 6	Blue +	14 to 16
4 to 5	Red −	12 to 14
3 to 4	Darker Red − −	10 to 12
Below 3	Darkest Red − − −	Below 10.

The *red* indicates the colour of *bright arterial blood*, full of *life, vigour, and health*, a fit emblem of *low* mortality; whereas *blue* is the colour of *venous blood, used up, effete, incapable of vitalization*, noxious, and associated in our minds with *disease* and *high* mortality. The above colour-scale answers for all diseases; the death-rate figures alone require altering and arranging after the same plan as the Cancer-scale. It will be noticed in these maps that the same colour-scale serves for two very different sets of death-rates.

Map 1. "*At all ages.*"

The first thing that strikes us on looking at this map, is the preponderance of *red* or *low* mortality colour, showing clearly at a glance that the area before us is not one of the haunts, as a whole, of the malignant diseases classified under the heading of *Cancer.* The death-rate from *Cancer* among females during the 20 years 1851–1870 throughout England and Wales amounted to 4·81 to every 10,000 females living during that period; the number of deaths certified and registered as caused by this disease amounting to nearly one hundred thousand (99,533). The enclosed figures in the maps represent the death-rates in accordance with the scale between the two maps.

The next feature in the map that attracts us, is the *blue* colour, indicating a high mortality, or at least one above the average, that distinguishes the districts through which the fully formed river *Eden* has its course, and the riparial lands of which it seasonally floods; these districts are *Penrith* and *Carlisle.* In the map of the first edition the districts traversed by the rivers Derwent and Eamont are coloured *blue* (—), the latter, the effluent of Ullswater, enters the Eden at right angles, a position favouring floods, whilst floods along the Derwent (Cockermouth) are less frequent. In 1851–60, the death-rate in *Cockermouth* was 4·69 or just *above* that of the decenniad 4·33; whilst that of West Ward was 4·84, so was coloured *blue.*[1]

Map 2. *At and above* 35 *years.*

By eliminating all females below the age of 35, in fact by confining ourselves to those females whose age subjects them to the possibility of dying from Cancer according to the table of deaths at different age-periods given above, our factors

[1] The large coloured map of *Cancer* for England and Wales that illustrated the First Edition may be still obtained separately at Messrs. Baillière & Co., 20, King William Street, Strand, W.C.

become more trustworthy, and certainly more valuable and interesting, for whilst the number of deaths is practically not reduced, two-thirds of the female population, or all under 35 years of age, being worse than useless in our calculations, are cut off. Before leaving Map 1, it would be well to compare it with Map 2, and observe what a great resemblance there exists between the two as to colouring; showing how the mortality from Cancer among females above 35 dominates the death-rate at all ages. The mean population of females above 35 throughout England and Wales averages about one-third of the entire female population. Thus, in 1851–1860 the mean female population was 9,718,174 "at all ages," but only 3,011,401 of these were above 35 years of age, or a little less than one-third. In 1861–1870 the mean female population was 10,971,649, of whom 3,441,783 were above 35 years of age, or at an age when *Cancer* is most fatal.

In 1851–60 one-third of the female population equalled 3,259,087, and in 1861–70, 3,657,219; whilst the number of females at and above 35 years of age, at each of the above decennial periods respectively, amounted to 3,011,401 and 3,441,783 respectively.

In 1881 the total female population amounted in Cumberland to 125,901, and in Westmorland to 32,729, of whom 41,967 and 10,909 respectively were at or about 35 years of age; or equal, in Cumberland, to 30·72 per cent., and in Westmorland 31·67. In England and Wales, 1851–60, the percentage was 30·97, and in 1861–70, 31·96.

The Distribution of Cancer in the Registration Districts. Map 2. At and above 35 years of age (Females).

The average death-rate throughout England and Wales from Cancer among females amounted in 1851–60 to 12·98 to every 10,000 females living, and in 1861–70 to 15·63; and the mean for the 20 years 1851–1870 was 14·40, which has been adopted as the standard on the scale; all death-rates

above it being coloured *blue*, and all *below* it *red* in different shades.

I. The first thing the reader will notice is the continuous group of the *darkest red*, or lowest mortality, stretching from *Alston* in the N.E., to *Whitehaven* in the W. This group has a mean annual death-rate of 9·01, or 5·39 *below* the above standard.

II. The next point will be the area coloured *blue*, consisting of the districts of *Carlisle and Penrith*, the mean death-rate of which is 15·71, or 6·70 above that of the *lowest* mortality group, and 1·31 above that of England and Wales for the same period.

III. All the other six districts have a death-rate just below the average or standard, with the exception of *Ulverston*, which has a lower mortality than the other five. The mean death-rate of the *five* districts north of the great Transverse Ridge amounts to 13·11, or 1·29 *below* the average; whilst that of the exceptional district, *Ulverston*, has a death-rate of 10·54 or 3·86 below it. The mean county death-rates from Cancer among females at and above 35 years of age during the 20 years 1851–1870 were as follows:—

Cumberland, mean female population at and above 35 years, 34,120, among whom died from Cancer 889. *Westmorland*, mean population, 9,803; total deaths, 192. *Lancashire*, part of, total population, 4,981; total deaths, 105.

Death-rates from Cancer among females, 1851–70:

Cumberland	13·02
Westmorland	9·79
Lancashire, part of	10·54
Mean for the whole area	11·11 or 3·29

below that of England and Wales.

Distribution of Cancer (Males) "at all ages."

The average death-rate "*at all ages*" among *males* from Cancer throughout England and Wales during 1851–1870, amounted to 2·20 annually to every 10,000 males living, which is less than half of what obtained among *females*, 4·81. When discussing Map 1, showing the distribution of Cancer "at all ages" among *females*, we found that the preponderating colour was *red*, indicative of *low*, death-rates from this cause. Now if we colour a blank map according to the scale for the male death-rates, we shall find that *red* is still the preponderating colour, and that *blue* characterizes the same districts as in the map of the females; on the map of males, however, the colouring is not so pronounced, although it follows the type of a group of low mortality district. It will, however, be more satisfactory to compare the two distributions at and above 35 years of age, the period of life when, in both sexes, Cancer is most fatal. The table of death-rates at different age-periods, has been already given for *females*, that for *males* is as follows. The former table for females is here repeated for the sake of comparison.

Table of Death-Rates from Cancer at different Age-Periods.

	Males. (To every 10,000 *males* living at each age-period.)	Females. (To every 10,000 *females* living at each age-period.)
Under 25 years	0·15	0·16
Between 25 and 35 years	0·61	1·52
„ 35 „ 45 „	1·90	6·34
„ 45 „ 55 „	4·84	14·17
„ 55 „ 65 „	10·79	20·92
„ 65 „ 75 „	17·03	25·96
„ 75 and above	20·63	25·95

As no coloured map illustrates the distribution of Cancer among *males*, we may use Map 2 (*females* at and above 35 years), to illustrate what obtains among males at the same

age-period (at and above 35 years) and during the same twenty years' period, 1851–70.

I. The continuous group of *red* or *low mortality* districts which makes such a remarkable feature in Map 2 (females), is repeated in the hand-coloured map (males) from which this description is taken, although the colouring does not indicate the *lowest* degree as in the female map; still *all* the *low* mortality districts, from *Brampton* to *Bootle*, form a group corresponding to the *low* mortality series in Map 2 (females); the series, however, does not include *Whitehaven* which is coloured light *blue*. The mean annual mortality from Cancer among males during the 20 years 1851–1870, to every 10,000 males living at and above 35 years, was at the rate of 6·74, so that the scale standard would be represented by 7·0.

The low mortality group above described is represented by the following districts: *Brampton*, 6·68; *Alston*, 6·71; *East Ward*, 4·54; *Kendal*, 4·81, and *Bootle*, 5·26; mean death-rate for the whole group, 5·60, the scales adopted for the two sexes being the following:—

Scales of Death-rates from Cancer at and above 35 *years of Age.*

1851–1870.

England and Wales.

Males.			Females.
11 and above.	Darkest Blue	+ + +	18 and above.
9 to 11	Darker Blue	+ +	16 to 18
7 " 9	Blue	+	14 " 16
5 " 7	Red	–	12 " 14
3 " 5	Darker Red	– –	10 " 12
Below 3	Darkest Red	– – –	Below 10

II. In Map 2 (females) we found that there were only two districts that had a mortality from Cancer above the average, viz., *Carlisle* and *Penrith*. On the map of distribution among males, we find all the districts to the north of the great Trans-

verse Ridge coloured *blue;* in fact, besides the two districts named, all those coloured *light red*, except *Brampton* and *Whitehaven*, coloured *darkest red*, are coloured *blue*, indicating a mortality *above* the average, so that we may describe the distribution as a crescentic group of (*red*) low mortality districts, holding the remaining *blue* or *high* mortality districts within its horns, as when "the *new* moon holds the *old* moon in her arms." The significance of this form will be seen later on. This *blue* group, however, must be divided into three: (*a*) a *central* portion of high mortality, consisting in succession towards the north-west from the Valley of the Eden, of *West Ward*, 11·15; *Penrith*, 9·87; and Wigton, 10·94; giving the mean mortality of the three districts equal to 10·98. (*b*) To the north-east of this group is the one consisting of *Carlisle*, 8·87, and *Longtown*, 7·97, mean, 8·42; and (*c*) to the *south-west*, the two districts, *Cockermouth*, 7·38, and *Whitehaven*, 7·04, mean, 7·21; so that the *mean* of all the *blue* or high mortality groups named above amounts to 9·02, whilst, as we have seen, the mean of the *low* mortality crescentic group only reached 5.60; the mean for England and Wales being 6·74, and the standard 7·00. With regard to the central three groups, it may be noted that whilst *Wigton* had a *low* mortality "at all ages" in 1851–60 among *females*, and was so coloured in the district map of the first edition; it had a high *male* mortality, even surpassing that of the females, not only relatively but absolutely, and formed in this respect one of the few exceptional cases in which the *males* deaths exceeded those among the females. In 1851–60 the death-rate among *males* "at all ages" amounted to 3·61, and amongst females to 3·54; in the one instance it would be *above* the death-rate for England among males, whilst in the other it would be *below* that among females.

III. In a former paragraph, the lower mortality districts forming a red crescentic group, coloured *red*, were described as surrounding, or as it were, holding within its horns, all

the high mortality districts coloured *blue*. Now if we consult Map 2 showing the distribution of deaths among females at and above 35 years of age (1851–70), we shall be able to understand the simile better; for the distribution displayed on this map is on the same lines, in fact is only a variety of the same species of distribution. In both maps the low mortality or red districts form themselves into crescentic groups occupying the same areas. For instance, in Map 2 (females) we see the *lowest* mortality districts stretching around and bordering the area from *Alston* to *Whitehaven*, between the extreme points or horns of which lie the *blue* districts of *Penrith* and *Carlisle*, and the other districts coloured light red, indicating a mortality only just below the average. If the reader will now include *Brampton* in the red crescent and exclude Whitehaven, he will comprise all the districts in the low mortality crescent-group on the Map of Cancer Distribution among Males at and above 35 years of age during 1851–70, the mean death-rate being 5·60. If we now suppose all the *light red* and *blue* districts to be coloured *blue*, indicative of their having death-rates *above* the average, and include Whitehaven with them, we shall then have a conception of a Map of the Geographical Distribution of Cancer among Males at the age-period mentioned.

Physical and Geological Facts coincident with the Disease-facts.

The Crescentic Low Mortality Group (*Males*).

Physical Facts.—It will be seen by the *contour map* that elevated *dark brown* areas above the 1,000 feet contour-line characterize Brampton, Alston, East Ward, and the northern parts of Kendal, Ulverstone, and Bootle.

Geological Facts.—All the above districts are found on the geological map to lie more or less upon the *Carboniferous Limestone Series* (d_2), and that through Kendal, Ulverstone, and Bootle districts, is superadded the *Coniston Limestone* (b_3), which is seen running from the *Shap-granite* (G) in a

south-westerly direction across the three named districts to the right bank of Duddon Mouth. Again it will be seen that along the southern boundary of the same three districts that the *Carboniferous Limestone* (d_2) comes to the surface at the mouths of the rivers and their riparial districts; where, when floods take place, it is ready to correct the evils attendant upon vegetable and animal decomposition, probably by destroying some constituent of the septic mass that would otherwise have proved favourable for the culture of some air- or water-borne wandering microphyte, or pathogen.

The high mortality districts included within the crescentic group of low mortality (males).

It will be seen by the contour map that the most populated parts of the districts characterized by high mortality are situated principally below the 250 feet contour, or between it and the sea-coast; again, from *Longtown* to *Whitehaven* all the principal rivers on the west traverse the low-lying areas, mostly glacial-drift covered, on their way to the sea—the areas mostly subject to floods when they do take place.

The highest mortality from Cancer among *males* above 35, during the 20 years, occurred in the district of *West Ward.* The valley of the Eden as it crosses this district is much bestrewn with glacial drift covering the red *Permian* and other sandstones; and we find, too, that the river Eamont, the effluent of Ullswater, joins the river Eden at *right angles*, a direction most favourable during heavy rain and sudden thaws to the production of floods. In West Ward the death-rate among *males* was 10·54, and *females* 14·77. We have already referred to the other two districts belonging to this central group of high mortality, Penrith and Wigton.

The following facts should be noted with regard to the distribution of Cancer among males and females in the Cumbrian and Lake district.

1. That the *low mortality districts* occupy similar if not almost identical areas among males and females.

2. That this low mortality is coincident with the presence of *limestones* either belonging to the *Coniston* (b_3) or the *Carboniferous* (d_2) series.

3. That the position of these *calcareous* rocks in these districts vary; in some they characterize the highest and least populated areas of the districts; as in West Ward, Penrith, Brampton, and Longtown; whilst in other districts they occupy a prominent place in the geology as in *East Ward*, an elevated district where the river Eden is not fully formed, where floods are soon carried off when they do occur, or else, as we have seen, they characterize the low-lying riparial areas around the lower courses of rivers which are fully formed and are well known to flood their banks seasonally; the geological map shows the position of these rocks which enables them to exert their influences on the *débris* of floods.

4. That the low-lying districts coloured *dark blue* on the contour map, indicating a level between the 250 feet contour and the sea-level, are more or less associated with a mortality *above* the average as among males, or only *just below* it as among females, except where the low ground bordering the sea rests upon Carboniferous Limestone rocks, as in *Kendal*, *Ulverstone*, and *Bootle;* which, moreover, are characterized by the belt of Coniston Limestone crossing in a south-westerly direction the higher parts of the two former and the mouth of the Duddon in the last.

It has thus been shown that the two distributions of Cancer among *males* and *females* are practically of the same species; that they should differ was to be expected, but the difference amounts only to such a variation as to qualify the distributions as varieties of the same species.

5. And lastly that *prevalence of Cancer* in the Cumbrian area, as throughout Great Britain, is associated with lowness of area, consisting of more or less retentive soils, overlying clayey rocks, and subject to seasonal river floods; that bring down from cultivated and uncultivated land, and inhabited

localities, much refuse made up of vegetable and animal matter, which ultimately is subject to decomposition, during which soils are formed that microphytes and other minute organisms rejoice in as conducive to their culture and propagation. These microphytes find their way into the water and the air of the locality where they have been naturally cultivated.

Having now exhausted all the statistical data that are available for studying the geographical distribution of Cancer among *males* and *females* separately, inasmuch as the present Registrar-General has mixed up the sexes together under the head "persons" in his decennial supplement for 1871–1880, we can only now bring together what facts remain to us as to the distribution of Cancer generally, without distinction of sexes, during the last 30 years.

We shall therefore now treat *Cancer* as a cause of death among the population of this area at "all ages," and without reference to sex, with the view of ascertaining whether the typical features of the geography of this cause of death are of sufficient character as to impress themselves upon us as they did when plotted on the Cancer Map showing the distribution among females during 1851–1860, notwithstanding that 20 years' more facts have been added, and 30 years of registered deaths form the basis of our calculations. These facts are epitomised in the form of death-rates in the following table.

In this table are represented the death-rates from Cancer among the mixed male and female populations of each district: the *plus* + and *minus* – signs are used to mark whether the death-rates were *above* (+) or *below* (–) that for the decenniad throughout England and Wales, which is given at the head of each of the death-rate columns, whilst that for the combined area is at the bottom.

Table of Mixed Death-rates from Cancer, i.e. those of Males and Females taken together during the Thirty Years 1851–1880.

	1851–1860.		1861–1870.		1871–1880.		Mean. 1851–1880.	
	Death-Rate.	Above + Below −	Death-Rate.	Above + Below −	Death-Rate.	Above + Below −	Death-Rate.	Above + Below −
England and Wales.	**3·17**	**0**	**3·87**	**0**	**4·73**	**0**	**3·92**	**0**
Alston	0·78	−	3·62	−	5·04	+	3·14	−
Penrith	4·29	+	4·38	+	5·70	+	4·79	+
Brampton	2·44	−	4·87	+	6·13	+	4·48	+
Longtown	2·72	+	4·29	+	5·63	+	4·21	+
Carlisle	3·34	+	5·20	+	6·21	+	4·91	+
Wigton	3·57	+	4·64	+	6·33	+	4·84	+
Cockermouth . . .	3·46	+	3·38	−	4·72	−	3·85	−
Whitehaven . . .	2·31	−	2·69	−	3·14	−	2·71	−
Bootle	2·22	−	2·79	−	2·31	−	2·44	−
East Ward . . .	1·53	−	3·02	−	4·70	−	3·08	−
West Ward . . .	4·20	+	4·29	+	5.46	+	4·65	+
Kendal	1·93	−	2·90	−	4·56	−	3·13	−
Ulverstone . . .	1·96	−	2·44	−	2·66	−	2·35	−
Cumberland, Westmorland, and The Lake District	2·67	−	3·73	−	4·81	+	3·73	−

\+ *The Plus* } denote that the *mixed death-rates* (males and females)
− *The Minus* } were either *above* or *below* the *decennial averages* for England and Wales in each district.

By the above table it will be seen that, during the three decennial periods, *Cancer*, as a cause of death among the mixed male and female populations of the thirteen districts, has reached a mean death-rate *above* the average of the country in six out of these districts, and that *four* out of the six have been characterized by a *high* mortality during the whole of the three decennial periods, namely, *Penrith*, *Carlisle*, *Wigton*,

and *West Ward*, having a mean mixed population of over a hundred thousand individuals (100,783).

On the other hand, *seven* districts had a mean mortality *below* the average, out of which *five* had a *low mortality* from this cause during each of the three decennial periods, namely, *Whitehaven*, *Bootle*, *East Ward*, *Kendal*, and *Ulverstone*, having a mean mixed population of over one hundred and fifty thousand (156,294).

The first four districts having a persistent high mortality are characterized by the fully formed rivers of the *Derwent*, *Eamont*, and *Eden*; the clays of *the glacial drift*, covering large areas of Red Sandstone and Carboniferous Limestone, and the occurrences of seasonal floods. The five last districts having a persistent *low* mortality, are characterized by elevated sites on the Carboniferous Limestone, and although traversed by fully formed rivers which seasonally extravasate their riparial boundaries, do so in localities near the low-lying areas, which overlie the Carboniferous Limestone (d_2), that is seen to skirt the southern portion of Kendal, Ulverstone, and Bootle.

This coincidence of low mortality from Cancer in localities characterized by *limestones*, would not perhaps have been so much dwelt upon, had not the same fact occurred throughout England and Wales wherever the limestones occur; whilst on the other hand, wherever clays and floods are associated, high mortality from Cancer at once prevails. These remarkable facts were brought before the medical profession at the Congress of Hygiene in August last, and I will conclude this section with a quotation from the paper that I then read, not only for the purpose of drawing attention to these facts, but to lay before the Congress the action of the present Registrar-General, who, as I have before mentioned, has so mixed up males and females together in the 630 Registration Districts, that the work of studying their diseases separately has been stopped.

In the paper referred to above I gave the following facts, showing the difference in the mortality from Cancer among females at and above 35 years of age.

1851-1870.	Clay and Flooded Groups.	Chalk (Limestone) Group.
1. London Basin	18·21 + ...	14·02 –
2. Hampshire	none in the area selected...	11·27 –
3 The Lake District ...	15·71 + ...	9·27 –
Mean	16·96 +	11·55 –

Section II.

The two Sets of Facts require to be Linked—Their practical Value even without being so—1868, when the Geographical Distribution of Cancer was first Announced—The Study of Specific Causes—A brief Résumé of Discoveries in Bacteriology—Ehrenberg, 1828—Yeast—Cagniard Latour—1837—Schwann—Zymotic Diseases—Dr. William Budd—Typhoid Fever—Sir Thomas Watson—Sir John Simon, 1860—Cause of Inflammation—Dr. Burdon Sanderson—Contagium—Professor Hallier—Dr. Klein—Microphytology—Grouping of Fungi—Ehrenberg—Cohn's Classification — Schizomycetes — Billroth—Lankester—Klebs—Nägeli—Cryptogams—Phanerogams—Ancestors of Fungi—Mycelium of Carboniferous Age—Professor Williamson—Habitat of Myerophytes — Flügge — Flooded Lands and Saprophytes — Tropical Climates—Dr. Koch—Cholera Bacillus—Increase of Cancer—Progress of Agriculture—Drainage and Sewerage—Floods increasingly Foul—Soil in Cryptogamic Culture and Propagation—Difficulty in finding Appropriate Soil—Tubercle Bacillus—Koch—Viability of Fungi—Manured Fields—Pathogenic Forms in Earth—Tetanus—Acid-forming Power of Microphytes—Whitbarrow—Nitric and Carbonic Acids—Relation of Limestones and Clays to Culture of Microphytes—Floods spread Soils favourable to Culture of Bacilli, etc.—Phanerogams and Calcareous Soils—Sir James Paget's Views—Extracts from his "Morton Lecture"—On Cancer and Cancerous Diseases—Messrs. Ballance and Shattock—Tuberculosis—Syphilis—Vegetable Pathology—Xylomata—Galls—Chauveau—Bistournage — High and Low Mortality Districts (Cancer)—Clays and Limestones—Floods—Difference in Mortality—Statistics—Relations of Phanerogams and Cryptogams to Calcareous Soil—The Connection between the Geographical Distribu-

tion of Heart Disease and the Wheat-yield in England and Wales—The Relation of Soil to the Crop—Vegetable Decomposition—The Delta of the Ganges—Soonderbuns—Cholera—Major Graham—The Fevers of Greece—Hippocrates—Littré—Messrs. Ballance and Shattock—Their Joint Paper on the Cultivation of Micro-organisms from Malignant Tumours—Factors Predisposing to Successful Invasion of Disease—Racial Characteristics—Physical Characters—Dr. John Beddoe—Heredity—The Author's later Investigations—The Effect of Different Soils on Microphytes—Suggestions as to the Cause of the Difference in the Prevalence of Cancer in Clay and Limestone Areas.

The two sets of facts dealt with in the first section of this chapter, namely the prevalence of *Cancer* in some localities, where are coincident floods and clays, and an infrequency in places characterized by elevated sites and limestone formations, or even by sites subject to floods but within the immediate influence of calcareous rocks, such as the Coniston Limestone of the Lower Silurian and the Carboniferous or Mountain Limestone of the Carboniferous ages, require to be linked together by some other facts, which shall complete the chain of events in the natural history of this class of malignant diseases. Nevertheless the two sets of facts, even whilst presented to us for use empirically, are of value in the practice of medicine, for the fact that high mortality from Cancer is associated with flooded, low-lying, and clayey areas, from the Land's End to Berwick Bridge, for the last thirty years, is one that will be remembered and acted upon by those who have the responsibility of advising those where to and where not to reside, whom hereditary taint or other reasons have induced to seek their advice.

Since 1868, when *Cancer* was first shown to have a geographical distribution in England and Wales, a great increase in our knowledge of the share that certain lowly forms of life take in the diseases of man and other animals has been acquired. These life-forms are spoken of as *microphytes*, or small plants, *fungi*. In 1828 Ehrenberg first published his investigations as to the existence of microscopical living or-

ganisms in dust and water. In 1836 the vegetable nature of Yeast was discovered by Cagniard Latour, and Schwann had demonstrated their cell form and vegetable character.

Schwann in 1837 asserted as the result of his experiments that the atmospheric air was constantly laden with fermentative and putrefactive germs, and also that certain fermentative processes were dependent on the access of living organisms (Flügge, p. 71). Diseases were called *zymotic* in consequence of their being supposed to be the result of certain fermentative processes set up in the blood by certain specific ferments.

Dr. William Budd worked with all his genius and industry in search of the truth with regard to the relation of these micro-organisms to disease—typhoid fever especially. Of the few who looked on with interest on his work, was Sir Thomas Watson, whose unfettered and independent mind watched with deep interest Budd's investigations, and gave him the support of his respected name. Budd came to the conclusion that all communicable diseases are propagated by micro-organisms. In the year 1860 we find the stronghold of old notions with regard to the cause of inflammation attacked. Up to that date Dr. Burdon Sanderson states: it was assumed without question that whenever inflammation occurs in consequence of an injury, whether chemical or mechanical, the *apparent* cause of the morbid process is the real one. Since that time it has gradually become clear that in the majority of instances this is not so; and that, however direct and simple may be the reaction which follows, the result does not occur unless there be present at the seat of injury another condition—something analogous to the contagia which are the acknowledged indispensable agents in the production of specific diseases. So that in all these cases we have to distinguish between the *contagium*, or proximate cause, and the mechanical or chemical injury by the co-operation of which it is enabled to act.

Now the pathologist, says Sanderson, who first referred to *contagium* as an element in the causation of inflammation, was John Simon. In 1870, the same author adds, Mr. Simon in republishing the article in Holmes' *System of Surgery*, quoted, recognised in a note the probability that the doctrine which had a little before been set forth by Professor Hallier, that specific contagia are in their essence living *microphytes*, was true.[1] From that time to the present, evidence has accumulated in support of that view, and it must be gratifying to Sir John Simon to be able to refer in 1890 to the results of work that was the outcome of investigations made in 1870, the very foundations of which had been laid on bedside experience, when through the short cycle of twenty years' growth it was destined to return to the bedside again, with the disease at least unmasked if not converted into a preventative remedy.

Speaking of the zymological studies which have been diligently pursued by Dr. Sanderson and Dr. Klein, and their assistants, or Dr. Thudichum's singularly arduous undertaking in respect of the chemistry of the nervous system, Sir John Simon alludes to Dr. Klein's work in the *microphytology* of the morbid contagia, and states that during those years this observer has not only made large additions to previous knowledge of the habits and modes of action of *contagia* within the animal body affected by them, but has succeeded in clearly identifying and isolating the contagium of the pneumo-enteritis of swine, and the contagium of foot-and-mouth disease of farm stock.[2]

It will be observed that the term *phyte* (φυτόν) a plant—a small (μικρός) plant, is used throughout. In fact, before 1860, although little was known about these lowly vegetable

[1] *The Lancet*, 1891, vol. ii., p. 1027.

[2] *English Sanitary Institutions*, etc., by Sir John Simon, K.C.B., Cassell & Co., London, 1890, p. 413.

forms, they had begun to be associated with fungi by Nägeli, who had named them *Schyzomycetes* in 1857, and even Leeuwenhoek in the 17th century had figured *bacteria*, and in 1773 O. F. Müller had examined several important forms.

In 1830 *Ehrenberg* had begun to group these *fungi*, so that in 1838 he had divided them into four genera containing sixteen species. The results of Cohn's labours in this direction were published between 1853 and 1872.

In 1872 Cohn's classification of *Bacteria* was published; this important work extended to 1875, and ever since that period has exercised a powerful influence in directing the minds of students investigating these organisms.

Cohn had discovered in 1857 that *Schizomycetes* produced *spores*. In 1876 he had seen the spores germinate, and subsequently Koch, Brefeld, Pratzmowski, van Tieghen, De Bary and others confirmed his discoveries in various species.

Cohn was of opinion that these *Schizomycetes* were constant in form, but Lankester pointed out that *Bacterium rubescens* (since named *Beggiatoa roseo-persicina*, so frequent in impure ditches and ponds, passes through conditions which would have been described as so many separate species or even genera; that in fact, forms known as *Bacterium*, *Micrococcus*, *Bacillus*, *Leptothrix*, occur as *phases* in one life-history—Lister at the same time entertained similar views. *Billroth* too, in 1874, announced that various "form-species," and "form-genera" are only different states of one and the same organism. In 1875 Klebs, and in 1877 Nägeli gave in their adhesion to the views of Lankester. Later still the researches of Cienkowski, Zopf, Kurth and De Bary have rendered it clear that forms employed by Cohn to define genera and species occur as phases in one and the same life-history. Zopf showed in 1882 that minute spherical "cocci," short rodlets "bacteria," longer rodlets "bacilli," filamentous "leptothrix" forms, as well as curved and spiral

threads "vibrio," "spirillum," etc., occur as vegetative stages in one and the same *Schizomycete*.[1]

These vegetable forms that have been proved to be the causes of fermentation, putrefaction and disease, belong to that division of the Vegetable Kingdom which is characterized by propagation by means of spores—*Cryptogams;* the other great division known as *phanerogams*, on the other hand, bear flowers and produce seeds in which the various parts corresponding to the future structures of the plants are present (Flugge, p. 101). The cryptogams are flowerless and propagate by means of *spores* just mentioned, that is to say by small cells, in which the future structure of the plant is not distinguishable, and when present in large numbers resemble one another (Op. cit., p. 101).

These *fungi* have a long ancestry, equal in point of pedigree to the *algæ*, and perhaps preceded in this respect the more highly endowed *phanerogams*, for whose reception on earth these lowly plants may have prepared the way among the primeval rocks of the earth's crust. At all events geological record establishes the fact that traces of *fungi* have been found in the Carboniferous rocks, for their *mycelium* has been preserved in woody stems of Carboniferous age.[2]

From the earliest dawn of vegetable life it is probable that these cellular *microphytes* have borne their share in the economy of nature; parasites many of them are, and parasitism seems to have characterized them during the Carboniferous age, for their spawn was found attached to a flowering plant.

The Habitats of Microphytes.—(Bacteria, etc.)—At present we are not in a position to discuss the habits of those organisms that are associated with floods, simply because

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[1] *Encyclopædia Britannica.* Last ed., vol. xxi., pp. 399 et seq.

[2] Professor W. C. Williamson, *Geological Address, British Association,* 1883. *H. B. Woodward,* Op. cit. 148.

we know nothing of their relation to the malignant diseases under discussion; we do know, however, that many of these fungi rejoice in moist death, whether of vegetable or animal, or both combined, and that dead putrid organic matter is the soil in which such plants mostly thrive. Flügge tells us that in addition to ground water, which is chiefly employed in drinking and household purposes, the water which flows on the surface of the ground often serves as a means of transport of *saprophytes* and at times of *pathogenic bacteria.* In fact the water in gutters, streams, and rivers is particularly dangerous, because it not unfrequently serves the double purpose of taking up and removing waste water of the most various kinds, and at the same time supplying water for household purposes.

Further, *stagnant* and *superficial collections of water*, the *muddy banks of rivers, and fields* which are *at times submerged*, are probably of special importance in the etiology of many infective diseases. They act not only as means of transport for all sorts of disease germs, but they also in all probability facilitate the growth and multiplication of the parasites.

It has been shown that *anthrax*, *typhoid*, and cholera bacilli can grow well on moist, dead portions of plants, such as often occur in enormous quantities on the banks of rivers in *regions which are flooded.* In these places the bacteria mentioned find a favourable temperature, as well as the necessary moisture and nourishment, during a great part of the year, and if a saprophytic existence of parasites is possible anywhere in the natural surroundings of man, it must be here.

Such a saprophytic growth is most likely to occur in tropical climates; it was thus that Koch succeeded in demonstrating the presence of cholera bacilli in one of the Indian tanks, and proving that a marked saprophytic multiplication of the bacilli had occurred on the banks of the tank (Op. cit., p. 715).

These microphytes not only gain access to the interior of living bodies by means of water, but through the atmosphere; and although during the time of flood the danger might be least, we have always contended that the great season of danger is after the waters have drained away and the dead vegetable and animal matter have commenced to offer temptation in the shape of eligible soils to the vagabond microphytes floating either in the water or the air.

Alleged Increase of Cancer.—It is now asserted that the mortality from Cancer is on the increase. In 1890 I was called upon to make some remarks on this subject, which I subjoin.[1]

We have first to consider briefly the growth of the population. Dr. Farr's statistics which I have used in my inquiry date from the decennial reports for 1851–1860. From 1851 to 1881 the population of England and Wales grew from 17,927,609 to 25,974,439, or from a density of 308·1 to the square mile to one of 446·4; an increase equal to 8,046,830 persons, or 138·3 to a square mile respectively; an increase almost equal to the whole population in 1801, which then only amounted to 8,892,536, or 153·0 to the square mile; so that the enormous increase alone in the population during the 30 years 1851–1881 equalled the entire population at the beginning of the century, less 845,706; and as to the density, the increase alone in this respect equalled that in 1891, less 14·7 persons to the square mile. Whilst this great increase was taking place in the population on the land, the areas of the watercourses which carry off their sewage remained the same. Since 1851, among the most important improvements in agriculture must be ranked the drainage of the land, which has been carried out to an unprecedented extent since then. The effect of these operations has been to drain the land of excessive moisture both completely and

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[1] *The Lancet*, vol. ii., 1890, p. 317.

rapidly, and at the same time to afford facilities for heavy rainfalls rapidly to affect the watercourses; hence it is a matter of late experience that, since this system of drainage has been adopted, the floods have not only been more sudden and frequent, but their waters have risen higher, and as a natural consequence have covered larger areas. This increase in the number, suddenness, and extent of floods has been coincident with the increase of cancer among females in the flooded areas. Lastly, the mode of the removal of sewage from houses, under the several Public Health Acts which have come into operation since 1851–60, have largely contributed to increase the foulness of the river waters. Under these Acts a vast number of cesspits and other receptacles of sewage and filth have been done away with which formerly slowly drained their contents into the soil. This old-fasioned method was contemporary with defective town drainage, which, before the general introduction of the water-carriage system, conveyed the sewage slowly away to the rivers. To this succeeded the water-closet epoch, during which sewage was rapidly forced into the drains by a large amount of water. Then the old town drains were found inadequate for the extra work put upon them, and extensive town-drainage works were carried out all over the country to meet these exigencies. Then, again, it was found that the old-fashioned method of water-supply by means of wells and watercourses was not equal to the requirements of the new system of water carriage, the wells becoming exhausted and the watercourses polluted from the rapid introduction of filth into them by the large sewers. To meet this difficulty fresh sources of water were sought for and found, the result being that an enormous amount found its way into the sewers, which rapidly carried their contents into the watercourses, that became more and more polluted, and in too many cases remain so, notwithstanding the Rivers Pollution Commission and the feeble Sanitary Acts that fol-

lowed its reports. I have said enough to show how our floods have been gradually increasing in suddenness, extent, and foulness during the last forty years, and we all know that the number of registered deaths from cancers has been increasing coincidently, almost *pari passu* with the increase of this flood-nuisance, which is a disgrace to sanitary science and the cause of many more preventable deaths than even cancer contributes to the mortality records of our country. Until this growing evil is checked, we may expect the local prevalence and general increase of cancer and other diseases to continue.

I must refer my readers to special works on micro-organisms, where they will find described the various artificial soils that are best adapted for the culture of the *fungi* which within the last twenty years have been shown to be in a few instances the links between the geological factors of local climates and some diseases of the blood and internal organs of man.

Some members of the cryptogamic divisions of the vegetable world are as fastidious as regards soil as any phanerogamic plants; and hence it is that in the laboratory much difficulty is often experienced in procuring the right kind of artificial soil in which to propagate the separated microphyte. For instance, let us take the *tubercle bacillus*, which Dr. Koch found would not grow in any of the media (soils) commonly used for cultivation, but that it would grow in *serum* at the temperature of the body; he sought for and obtained a method of gelatinizing this liquid so as to give it the advantage of a concrete medium. For a succession of years serum rendered gelatinous by his method was the only soil on which this tuberculous bacillus was grown.[1]

On the other hand we find a whole host of lusty cryptogams capable of growing anywhere; in fact if we trace back

[1] Burdon-Sanderson, Op. cit., p. 1208.

their origin to remote geologic periods, we shall find that it was their viability amid adverse surroundings that rendered them fit for the work of preparing out of the rough rocks a soil adapted for the higher forms of vegetable life.

We are told on all sides that bacterial life in the soil is extremely active, that the soil is a chief reservoir for *bacteria*, into which the greatest parts of all fluids containing bacteria, almost all refuse water, excreta, etc., pass, and on the surface of which the germs which have passed into the air are again in great part deposited. Enormous numbers of *bacteria* have always been found in the soil by various observers.

Infusions made from manured field and garden earth, even though diluted a hundred times, still contain thousands of bacteria in every drop, and the ordinary soil of streets and courts also shows the presence of large numbers. Bacilli are present in much the largest numbers; but in the most superficial layers and in moist ground there are also numerous forms of micro-cocci. Some species are markedly prominent, and are found in the most varied places and at the most varied times in the soil, while they occur in other substances much less commonly.

Pathogenic forms are also not uncommonly found. Well-known inhabitants of the soil are the bacilli of *malignant œdema*, of *infective tetanus*, the *bacillus septicus agrigenus*, etc., which are commonly and almost exclusively found in garden or field earth. Pathogenic *bacteria* occur with such frequency in the soil that no material found in nature so easily produces infection as earth. Flügge adds that we have reason to assume that the infectious diseases caused by the soil would be more numerous, and would lead to the isolation of other species of pathogenic fungi, were it not that these œdema and tetanus bacilli are so widely distributed that they obscure the other infectious agents, and cause the death of the animal before other more slowly growing bacteria have had time to multiply. This marked infectious property of

the soil must evidently make us *à priori* inclined to accept the view that the *soil* is of special importance in the occurrence of human infectious diseases.

In a former chapter I remarked the fact that the *Carboniferous Limestone* at Whitbarrow and other localities in the districts characterized by a low mortality from Cancer, was eaten out into grotesque forms, showing the action of vegetable acids during the putrefication of vegetable matter; I will now note what has been observed by Warington and others on the formation of acids in soils.

Schlösing, Muntz, and later, Warington showed that the formation of nitric acid from the ammonia of organic substances is chiefly caused by lowly organisms; when soil has been heated, or treated with disinfecting means, it loses almost entirely this power, which is otherwise constantly observed. In like manner Wollny and Fodor are able to show that the formation of carbonic acid in the soil was entirely the result of the life of lower organisms. Gayon and Dupetit, as well as Déhérain and Maquenne, have furnished proof that when *oxygen* is deficient, a reduction of the *nitrates* to *nitrites*, *ammonia*, and *nitrogen* can be brought about by the *bacteria* of the soil. Many forms of bacteria (such as bacillus prodigiosus, cheese spirilla, Finkler's spirilla, typhoid bacilli, anthrax bacilli, staphylo-cocci) are able to oxidise *ammonia* to *nitric acid*.

There are many other interesting questions with regard to the effect of soil on pathogenic bacteria, and their behaviour in it: whether they multiply in it, and how the species affect each other.

There is also the interesting questions to be answered (not only by the pathologist, but by the botanist and the agriculturist): What are the relations of *limestones* and *clay* to the culture of microphytes? How do these formations affect the soils in which pathogenic and other fungi grow?

Up to the present time these lowly forms of vegetable life have been studied after they have entered the animal body; they will have in the sequel not only to be traced backwards to the mineral and organic soils where they were first sown, and where they thrive within the ordinary climatic surroundings of the country in which they are found, but forwards, as parasites, in the blood and organs of warm-blooded animals, in whom they have found a rich equable soil, and a temperature resembling that of the tropics.

Of one thing there can be no doubt, that the floods which we have found to be so universally coincident in Great Britain with high mortality from Cancer, contribute largely to the expansion of a soil in which microphytes rejoice and multiply. Again, this expansion takes place in the low-lying ground, which may in one district be of a retentive character like clay, or endowed with an acid-neutralising power like calcareous rocks. What are the microphytes favoured by the clays, and what are those to whom a calcareous soil is obnoxious? In studying these questions we must bear well in mind the chemical changes that all kinds of lowly life effect in the soil first and then in the air resting upon it.

We know that among phanerogams, some cannot live on a calcareous soil, whilst others rejoice in it and will thrive in no other; of these I have made a list which will be found in the Appendix as a beginning, and in the hope that at some future time I may be able to add a list of cryptogamic microphytes, illustrated by maps showing the geographical distribution of each pathogenic form, and the disease associated with it.

The Relations between Cancers and Cancerous Diseases and Specific Diseases.

Sir James Paget, in his "Morton Lecture on Cancer and Cancerous Diseases," delivered at the Royal College of

Surgeons of England, on June 11th, 1887,[1] indicated the relations between cancers and specific diseases, and assumed, as he did more than thirty years previously when lecturing on the same subject,[2] that we usually mean by *specific diseases* those in each of which the phenomena of common diseases, that is, of such as might be produced by various injuries or external irritations in any healthy person, are modified in some constant and definite manner which give them what we call *specific characters.* Every year's study since that time has made it more probable that what was then scarcely more than theory is now a sure general truth, namely, that each *specific disease* is due to the influence of a distinct morbid substance on some part or parts at which the characteristic signs of the disease can be and are manifested. Two conditions must coincide in each: the one general or diffused in morbid material in the blood; the other local, in some part with which this material produces disease. He used the vague term "morbid substance" on purpose that he might not pretend to definition or exact description.

The reasons are, indeed, constantly increasing for the belief that each of many *specific diseases* is due to changes produced, directly or indirectly, by a distinct species of minute parasite, a microbe, a bacillus, or some other vegetable of lowest organization, yet *specific*—as *specific* as any of the species much more highly organized.

Sir James Paget stated his belief *that micro-parasites, or substances produced by them, will some day be found in essential relation with cancers and cancerous diseases.*

Mr. Ballance and Mr. Shattock, he said, have indeed lately failed to find any; and if, in such a question as this, negative evidence could prove a negative, certainly theirs might

[1] Longmans, Green & Co., London.

[2] *Lectures on Surgical Pathology*, p. 784, 3rd Edition.

make us hopeless; but, he added, "I would not be so, especially if workers so earnest and so skilful as they are will continue the search; but for the present it will be best to use such terms as morbid material, virus or specific material, which, I think, we may be sure are at least not erroneous."[1]

Sir James Muir remarked, that the specific diseases which we believe and generally know to depend on morbid materials in the blood are very numerous—the eruptial forms, many of the diseases of skin, tetanus, hydrophobia, ague, and many more. They may be vaguely arranged in groups, each of which may include those which are most nearly alike; and the group by which the conformity of cancers and cancerous diseases may be tested is one that includes, as its chief members, syphilis, *tuberculosis*, glanders, leprosy, and actinomycosis, *each of which is known to have a distinct* parasite.

The lecturer then pointed out their most important general agreements.

First, let it be observed, he said, that they are included by Virchow among tumours, under the name of "granulomata"; and he doubted whether they can justly be excluded from the list for any reason which would not equally justify the exclusion of many of the cancerous diseases. Certainly, a *tuberculous* mass, such as one may find in the brain, or a syphilitic gumma in a muscle, or, still more, an actinomycosis in the jaw, has more of the general characters of a tumour than any rodent ulcer has or many cancers of the lip or tongue. It is at least evident that all these specific micro-parasitic diseases are, in their several measures and in some of their forms, morbid growths and self-maintaining.

All agree in this general character; they differ from one another in that each has a definite, characteristic, and diagnostic method of growing, as shown in its shape and in its substance, both tangible and microscopic, and in its relations

[1] The labours of these gentlemen will be again referred to (p. 334).

to the structures which it involves. In these respects they differ from one another about as much as any of them do from cancer. Besides, in all these diseases, as in the cancerous, the morbid growths are prone to special modes of degeneration, of partial decay, and of death; and they all tend to ulceration, each with a characteristic method shown in the shape of the ulcer, the structure of its boundaries, and its mode of affecting the parts on which it encroaches. And all the cancerous and the others alike are at some time infective; some by inoculation, all by invasion of adjacent parts, or by the transmission of materials, through lymph-spaces, lymphatics or blood vessels, to parts afar off.

Sir James Paget held that likeness in characters so significant as these is evidence enough of essential likeness and of close affinity in all diseases in which they are observed; and, therefore, that as we know that in *tuberculosis*, syphilis, leprosy, and the rest, there is for each a *specific morbid material* in the blood, so we should believe that there is at least one in cancer and cancerous diseases. The fact that it has not yet been found is not sufficient to prove that it does not exist.

Sir James Paget then pointed out the unlikenesses between these diseases, and remarked that cancer (1887) cannot be inoculated, and he did not think it contagious; but he believed that there are no positive generic unlikenesses; and as to the differences among them, the diseases that are certainly specific do not differ more from cancer than they do from one another.

With regard to tumours generally, Sir James Paget remarked that the whole study of tumours may, indeed, find admirable illustration in vegetable pathology. For example, some of the best evidences, even nearly the proofs, of the truth of Cohnheim's explanation of the origin of *tumours*, at least of many of the innocent ones, from portions of germinal tissue remaining undeveloped, may be seen in some

of the *xylomata* or *woody tumours* which may be found on trees, especially on beeches and cedar trees; for in these it is often evident, and always probable, that they have grown from buds or "sleeping eyes," as they have been called, which have remained for a time dormant, inactive, enclosed within normal structures, and these have, as it were, awakened and grown, after a manner of their own, with good woody tissue, but separate and purposeless. The Museum of the Royal College of Surgeons has specimens of such tumours—oval or nearly spherical masses of hard wood, well defined, concentrically laminated, either lying just beneath the bark or the branch or trunk in which they have grown, or nearly separated and cast out. Some of them, like *Polypi* or *Exostoses*, have pedicles continuous with the proper wood of the tree, and some have little outstanding twigs or branchlets, outgrowths from the buds in which they themselves had their origin.

And if these and the vast number of growths of the same kind observed in plants may illustrate the apparently spontaneous production of *innocent* tumours from germinal structures delayed in their development, so may *galls* illustrate the influence of a *virus* in exciting *morbid* growths. They may, indeed, illustrate both the conditions requisite for the manifestation of a specific disease—the specific morbid material and the part appropriate to its morbid influence.

Of these *galls*, which may fairly be called *heterologous*, there are more than a thousand forms already known, and each form is produced by a different material, a different *specific virus*, as we may safely call it, inserted by a different species of insect in a leaf or some other part of a plant. The very nature of the virus, which is usually inserted with the insect's egg, is unknown; but so constant are its properties, and so easily defined, that the specific characters of each insect are not more invariable than are those of the galls which it has made to grow. As we may describe the specific characters

of each insect, so may we those of its appropriate gall; and so may we, therefore, speak of each form of gall as due to a specific virus. This is especially seen when different kinds of virus are inserted in similar tissues, as when one finds three or four different galls produced by as many different insects.

In a large number of instances, Sir James Paget observed, we have no knowledge of the reason why the evidences of any specific diseases naturally appear in one part of the body rather than another ; no knowledge of the reasons for the different powers of resistance or self-maintenance in different parts. We cannot tell why *small-pox* is especially manifested at the skin, or *typhoid fever* in Peyer's follicles, or tertiary syphilis in a piece of periosteum or muscle. But in all specific diseases, and in *cancers* more than in any, parts are rendered apt to become the seats of diseases *after injury*, or in *degeneracies*, especially those produced by long-continued *irritation*. Thus *cancer* increases in frequency with the advance of age and of senile degeneration. Its frequency in the *breasts* and the *uterus* before old age coincides with what may be deemed their early senile changes, when they cease to be capable of their proper purposes. So, too, all cancerous diseases are apt to form in parts congenitally defective, and still more they follow *injuries* sometimes very quickly. More commonly still they appear in parts that have long been the seats of some "irritation," as we call it, as in the case of burns, or in syphilitic tongues or gums, or cheeks irritated by bad teeth, or in lips irritated by pipes, or tongues by hot tobacco smoke.

Sir James Paget was of opinion that the interest of the whole subject is in the biology of the primary cancer or cancerous diseases, and hoped he should be deemed to have shown that in this, as in all other characters of which he had spoken, there is so great a likeness and so little unlikeness between these diseases and the *specific ones* with which he had

compared them, that we may expect equal likeness in respect of the material on which they essentially depend. If it be so, he added, then we may justly hope that by careful study, both clinical and experimental, we may find the morbid material, *microbe* or *ptomaine*, or one or more of these products, to which cancer is due. And if this be obtained, then may we hope to be much nearer to a remedy, preventive or curative.

I have thus given the views of this eminent pathologist as fully as possible, first because they are the expressions of one whose reputation has long been held in the highest esteem, and whose researches and writings will in the future be regarded as classics in the history of science.

Before referring to the investigations of Messrs. Shattock and Ballance, quoted by Sir James Paget, I wish to call attention to the fact of injured parts being apt to succumb to the attacks from without of microphytes. Professor Burdon-Sanderson, in his Croonian Lecture,[1] states that in 1873 Chauveau made an experiment which was of fundamental importance. The operation of *bistournage*, which is used in France for economic purposes as a means of arresting the circulation in the testis by torsion of the spermatic arteries, and annulling the function of the organ in animals destined for the shambles, is *never known to be followed by any inflammatory reaction*, notwithstanding that the part is subjected to considerable violence. But if the animal is "prepared" by intravenous injection of microphytes derived from the pus of an infertile abscess, the contamination of the blood which the organ contains at the moment that the circulation ceases, converts the ordinary harmless manipulation into one fraught with danger to life in consequence of the intensity of the local reaction which it produces.

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[1] *Lancet*, vol. ii., 1891, p. 1028.

High and Low Mortality Districts.

In the series of papers I published in the *Lancet* in 1888,[1] I gave a list of twenty-two high mortality districts, which, during the decenniad 1851–1860, had a mean mortality from cancer among females at and above 35 years of age, equal to 19·82, and in 1861–70, 19·97 to every 10,000 women annually. These districts were scattered indiscriminately throughout England and Wales, and were all characterized by seasonally flooded clayey areas, on which the floods deposited an adventitious layer of *soil* consisting of dead animal and vegetable matter derived from sources already mentioned, and affording abundant pabulum for the culture and propagation of the microphytes that may fall upon it from the atmosphere. In 1851–60 these districts had a mean population of women at and above 35 years, equal to 81,763, among whom occurred 1,621 deaths from cancer; in 1861–70 the population had increased to 89,521, and the deaths from cancer registered 1,788.

In the paper on the Influence of Clays and Limestones on Medical Geography, which I illustrated by the geographical distribution of cancer among women above 35 years of age,[2] I gave the death-rates from certain low mortality districts, which were characterized by limestone and other calcareous formations, whether subject to floods or not. In the mountain limestone districts, the death-rate fell as low as 9·27, and in the chalk districts of Hampshire 11·27 to every 10,000 women living at the above age.

The mean death-rate from cancer and cancerous diseases among women at and above 35 years of age amounted during the twenty years 1851–1870 to 14·40 annually to every 10,000 women living.

During the same period, among the high-mortality districts referred to above, the mean annual mortality amounted to

[1] Vol. i. (1888), p. 366.

[2] Op. cit. p. 14.

19·89. During the same period among the *low*-mortality districts of Cumberland, Westmorland, and the Lake District, characterised by carboniferous and other limestones, the annual mortality only reached 9·27, or 10·52 less annually among every 10,000 women living above 35 years of age, which in the twenty years means a saving of 210 lives from cancer, when the mortality in the clayey and flooded districts is compared with what obtained during the same period in the limestone. These figures, compared with the mean death-rate from cancer among women throughout England and Wales during the twenty years 1851–70, would be as follows:—

Average for England and Wales ...	14·40.
Flooded and Clay Districts ...	19·89.
Limestone Districts	9·27.

The limestone mortality compared with clayey and flooded districts	In 20 years shows a saving of 210 lives.
The same compared with England and Wales	In 20 years shows a saving of 102 lives.

These are striking facts, and cannot fail to impress us with the necessity of studying local climates, not only in relation to man's immediate requirements as regards temperature, winds, weight of atmosphere, etc., but with due regard to the requirements of lowly vegetable organisms; the habits of these microphytic parasites have to be studied on the spot, and, wherever possible, *before* they have entered into the rich soil and tropical climate of their destined hosts. We have yet to learn much of their natural history; we have to hunt out their relation to the limestone-loving or clay-loving phanerogams; we have to discover the connection between our wheat-yield and the prevalence of rheumatism and heart disease: why these districts in which the malaria of rheumatism loves to dwell should be characterized by a *low wheat-yield*, whilst where rheumatism is infrequent and heart-

disease causes a death-rate below the average, the wheat-yield should be heavy.

We shall find in the sequel that there is not a valley-loop marked on the contour map but what would afford some insight into the life-history of many of these minute vegetable forms, which infest the lower stratum of the atmosphere and taint it so as to render it under certain conditions *malarious.* It is well known that the death and decomposition of all phanerogamous plants afford almost every kind of *soil* for the natural culture of microphytes. It is possible that in the future we shall be able to connect the soil with the crop, just as we do now in the case of flowering plants. Undoubtedly the pabulum afforded by decomposing plants differ widely in their character and adaptability for rearing the lower forms of fungi which the winds sow in them. It is well known that the decomposition of certain plants is attended with peculiar odours. Whilst the fallen leaves of a plant are rotting, there is frequently observed sickly odours, which emanate more powerfully from the fermenting masses under some trees than they do from others: in fact, I have heard it affirmed that persons accustomed to pass much time in or near large plantations of trees can distinguish by their sense of smell, unaided by sight, the kind of trees whose leaves have been shed upon the ground. I will select one instance from the many rivers, which fall into the sea around the warm belt of the earth, and have evil reputations for their malarious banks covered with dead vegetable matter, reeking in the sun, and affording fertile pabulum for microphytes, the Ganges—the delta of which river is covered on its south side for many miles in length with the Soondry tree (Herieteria robusta)—hence the name of the locality, Soonderbuns, which means *the great forest of Soonder trees.* This tract of land extends upwards of 180 miles along the coast of Bengal, and is notorious for the unhealthiness of its climate and its association with cholera. During June and July the rainy

season commences, inundations take place, the Ganges overflows its delta; and the result of this is that an immense mass of vegetable matter is destroyed. The extensive forest of the Soondry tree adds from its vast resources an immense supply of decaying matter, upon which the intense heat of the succeeding September pours, and causes it to exhale from the bed of stagnant waters its invisible but pestiferous poison.[1] The above note was made in 1856, at a time when cholera was still occupying our earnest attention; and then it was that the Registrar General (Major Graham) asked these important questions: "What is the cause of epidemic cholera? Is it the effused flaky matter, from the Indian population on the delta of the Ganges, driven about like the clouds of a *leavening dust* in the air and on the waters, that has reproduced itself, and has destroyed men all over the world, either dwelling quietly in their houses, or encamped on hostile battle-fields?"[2]

As evidence of the specific character of the pathogenic causes of remittent and other fevers in Greece being continued generation after generation, M. Littré remarks: "Les fièvres rémittentes et pseudo-continues sont à la fois celles que les observateurs modernes constatent aujourd'hui dans la Grèce, et celles que la discussion précédente a identifiées avec les fièvres décrites par Hippocrate. La Grèce antique et la Grèce moderne sont, à vingt-deux siècles de distance, affligées par les mêmes fièvres; et cela prouve *que les conditions* climatologiques n'y ont pas *essentiellement changées:* car l'homme, qui en est des réactifs les plus sensibles, y donne aujourd'hui comme alors la même réaction."[3]

Messrs. Ballance and Shattock, to whose work Sir James Paget referred in the passages quoted above from his Lecture on Cancer, have been continuing their researches, and at

[1] *Climate, Weather and Disease.* By the Author. London, 1855.
[2] *Reg. Gen. Weekly Return*, vol. xv., p. 502.
[3] *Œuvres d'Hippocrate*, tom. ii. p. 563.

the International Congress of Hygiene, in August, 1891, read a joint paper on the reasons for considering cancer to be an infectious disease. In this paper the authors state that they should regard carcinoma as having sometimes a purely local origin, in the same way that the tubercular infection-process may arise by direct inoculation, and remain a local though a spreading disease.

So, they say, we should look upon some examples of squamous-celled carcinoma of the lip in smokers, the early and free removal of which may be followed by complete cure of the disease. In other words, a patient suffering from a carcinoma, which has arisen as a local disease, and has not passed beyond the stage of local infection, may not only be relieved by the knife from the actual disease but freed from an almost certain secondary affection. The case, in fact, is exactly comparable to one of local tuberculosis arising from direct inoculation, or to external anthrax whilst it is yet a local process, and might be termed one of local carcinomatosis. Against this view, thus typically illustrated, the main argument adduced is that all those exposed to the local irritation arising from smoking should become therefore the subjects of carcinoma. But the efficient cause lies beyond the mechanical irritation which is but the partial cause of the disease; and the question resolves into this: Why are some persons infected under such circumstances whilst others escape? Reflection will suggest possible answers—the irregular distribution of the virus, the dependence of its efficacy upon the various elements of environment, personal predisposition, etc. Tetanus is more common in certain parts of the globe than others. The same is true of tubercle, to say nothing of those specific diseases, which like malaria or cholera are endemic. And cancer has, in the same sense, a geographical distribution.[1]

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[1] *An Exposition of the Reasons for considering Cancer to be an Infectious*

The authors briefly recounted their attempts at the cultivation of a micro-organism from malignant tumours, and their experiments of transplanting portions of living tumours removed from the human subject into various of the lower animals; and they can conclude that cancer is in all probability a micro-parasitic (animal or vegetable) disease, although no positive demonstration of the living nature of the virus is as yet forthcoming.[1]

Before concluding this part of the subject, I may observe that in all the low-lying valleys where cancer has a high mortality, we must never forget that many of them are unventilated by the prevailing winds, and that women at, and those above 35, who live in such hollows are liable to their mammary and uterine structures becoming relaxed and wanting in power to resist the invasion of disease, whether it attack them in the specific form of a microphyte, or "a chill." The same thing holds good in the valleys where the malarial air of rheumatism lurks, ready to invade the body wherever it finds an unprotected loophole.

Another question arises as to susceptibility, and so far as my own experience is concerned the great leveller is *atony*, and there can be no doubt but what some races are capable of propagating a healthy tone of structure more readily than others. There is one thing certain, and it is that the flabby and prone to disease of the present day do not inherit such constitutional characters through their Norse blood. One of the most interesting investigations that can be carried out in this connexion is that of studying the relation between certain varietal characteristics, such as stature, complexion, colour of hair and eyes, etc., and certain diseases—such as

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Disease, by Charles A. Ballance, M.D., F.R.C.S., Lecturer on Practical Surgery at St. Thomas's Hospital, and Samuel G. Shattock, F.R.C.S., Lecturer on Surgical Pathology at St. Thomas's Hospital, London: read at the International Congress of Hygiene, London, August, 1891.

[1] *The Medical Press and Circular*, Sept. 9, 1891, p. 249.

Cancer and Phthisis. In another part of this work I have indicated the localities where there are still traces of place-names remaining indicating the early settlements of the Norse and Danish settlers. The investigation so well begun by Dr. John Beddoe might be well carried on by the medical profession.

With regard to the influences of heredity, it is not to be supposed that either the cause of *cancer* or of *tubercle* need descend from parents to offspring, or that they do so descend, although it appears very certain that parents can transmit to their children a susceptibility to be attacked. Children born from parents whose systems have been injured by excessive alcoholic drink, although they would not be born with what caused the disease in their mothers and fathers, yet might prove inordinately susceptible to the effects of alcohol, although not invariably so.

Up to two years ago I certainly, so far as my investigations were concerned, had had no evidence before me to lead me to believe that cancer is due to a microphyte or other parasitic organisms. When, however, I commenced collecting materials for a new map with the added statistics of 1861–70 (Dr. Farr's), I determined to examine the distribution of deaths among males and females not only at "all ages," but at and above 35 years of age. The facts of the latter age-period, became at once three times more refined than those at all ages; and as the number of deaths registered was greater during the second decenniad than they had been during 1851–60, this increase in mortality, when plotted on a contour map, could then be traced upwards from the lower areas into the higher, and this extension was not only observed in the area under discussion, but found to obtain generally throughout England and Wales. This fact pointed to the existence of endemic centres, where occasionally submerged clayey soil and subsoil, and layers of dying and decomposed vegetable matter seasonally offered a resting place for the countless vagabond organisms that are

ever floating in the nether air. It must be remembered that the flood-waters in the Lake District are more highly aerated, in consequence of the numerous cascades, than those which submerge the riparial land traversed by sluggish rivers (p. 67). The decomposed animal and vegetable matter brought down by the floods would therefore be more completely oxydised and the entangled air would certainly have more effect on some of the entrapped micro-organisms than on others. Besides which, as some of these *sapro-* and *microphytes* are hostile to and destructive of others, it is possible that the soils from different rocks, such as *clays* and *limestones*, may in some instances favour the culture of the destroyers, whilst in others they may favour their victims, which, if of *pathogenic* species, would then have the greater chance of attacking man and other animals. This may be put hypothetically thus: suppose that over an extensive area of submerged land there exist in belts, alternating, perhaps, with each other, *clay rocks*, and *limestone rocks*, on which rests a layer of moist decomposed vegetable and animal matter, such as dead herbage and the output of sewers would form. Reasoning from what we know to take place in the case of natural phanerogamic culture, namely that the *clay soils* promote the growth of certain species, whilst they are hostile to others that thrive well in *limestone soils*, in which land the *clay-loving* plants fail to flourish, we may presume that, among the lower forms of vegetable life, such as microphytes, there exists a like susceptibility to differences in soil, and that whilst *clay soils* favour the culture of some pathogenic organisms, they may be infertile to other with which these have to struggle; and on the other hand that the *limestone* soils are infertile as regards certain pathogenic forms, whilst they promote the vigorous growth of the forms with which these disease-germs have to struggle, and thus bring about their local extinction, such as occurs among phanerogams. If this could be proved, we might perhaps solve the question,

how is it that, in the Thames Valley, all the highest mortality cancer districts (females at and above 35 years of age) are to be found characterized by *clays*, and all the lowest mortality districts by *chalk?* Or how is it that in Cumberland, Westmorland, and the Lake Districts, all the *highest* death-rates among women are found in the flooded *clay*, and all the *lowest* in the *limestone* districts?

Section III.

General Health and Zymotic Diseases—Mortality at all Ages from all Causes—Mixing the Sexes in the Registrar General's Supplement, 1871–1880—General Death-rate—Health of Cumbrian and English Lake District—Configuration of Land in relation to it—Chief Causes in the Fluctuation of the Death-rates—Zymotic Diseases—Origin of term Zymotic—Dr. Farr—Professor Tyndall—Dr. Koch—Pasteur—Dr. Keith Johnston—General Health, 1851–70, 1871–80—Tables—Effect of Local Climates—Group of Districts according to Aspects—Tables illustrating Zymotic Diseases.

Before describing the geographical distribution of Phthisis and Heart Disease, it will be well to give some facts with regard to certain other causes of death, which have been grouped together by Dr. Farr under the heads "Diseases of Stomach and Liver," "Diseases of the Kidneys," and "Childbirth and Metria;" and as a knowledge of the general death-rate is required as a standard of comparison, a table representing the deaths from "all causes and at all ages," will head this section. It is usual to calculate these rates to every 1,000 males or females living; but as they have been throughout this work given for every 10,000 living, this plan will be adopted for conformity's sake. To convert the 10,000 scale to the 1,000 the point (·) can be removed from between the third and fourth figures to the left between the second and third; thus, instead of 230·5 to every 10,000 living, read 23·05 to every 1,000 living.

Mortality "At All ages" from "All Causes."	1851—1860. M.	1851—1860. F.	1861—1870. M.	1861—1870. F.	1871—1880. M.	1871—1880. F.
England & Wales	230·5	213·2	236·1	212·8	226·1	200·0
					Sexes Mixed.	
Alston . . .	206·8	191·1	217·3	205·5	198·6	
Penrith . . .	188·1	191·8	194·9	182·8	186·7	
Brampton. . .	170·6	160·6	194·7	185·0	182·4	
Longtown. . .	172·8	175·7	184·6	190·6	196·0	
Carlisle . . .	240·6	222·7	249·2	229·6	231·6	
Wigton . . .	191·1	180·4	205·2	201·0	192·3	
Cockermouth .	230·0	214·4	238·6	226·3	210·8	
Whitehaven .	234·4	219·0	254·2	245·4	243·2	
Bootle . . .	168·2	157·0	185·4	174·5	179·2	
					M.	F.
Cumberland. .	201·3	190·3	213·7	204·5	221·7	208·1
East Ward . .	175·5	175·6	154·7	170·9	186·7	
West Ward. .	186·4	179·2	183·0	182·9	163·0	
Kendal . . .	189·4	181·7	188·4	182·4	176·4	
					M.	F.
Westmorland .	183·7	178·8	175·3	178·7	182·1	172·3
Ulverstone . .	200·0	200·9	210·0	202·7	236·2	
Lancashire, pt. of	200·0	200·9	210·0	202·7	236·2	

In the third decenniad in the above table the term "sexes mixed" occurs heading the last column. I have frequently had to mention that the present Registrar General in his Supplement for 1871–1880 has mixed up the deaths of males and females together so that in the district tables they cannot be discriminated. I append the passage referring to this departure from the rules laid down by the eminent statistician:—

"General Register Office, 28*th February*, 1885.

"The main portion of this volume[1] has been drawn up in *almost* the same form as that adopted in the two previous decennial supplements (1851–60 and 1861–1870.—Dr. Farr's).

[1] *Supplement to the Forty-fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England* (1871–1880). London: Eyre & Spottiswoode, 1885, p. iii.

The figures, however, in the District Tables (pp. 1–370) *now* relate to *persons*, and are not given, as was previously the case, for *males* and *females separately*. This change has been made not merely to economise space, but to give a *broader* and *therefore more secure basis for the calculation of rates*, and in order to meet the practical requirements of the Medical Department of the Local Government Board.

"To the Registrar General. (Signed) WILLIAM OGLE."[1] From the Census Returns of 1871 and 1881, with the ultimate object of being used by the Registrar General in the manner pointed out by Dr. Farr in his first two Supplements. However, whether the word "space" is a typographical error, in the place of which we should read "money," "trouble," or "work," does not matter, but what follows is unmistakeable and can hardly be attributed to the printer.

The whole of the carefully tabulated tables of the populations of males and females of each district, at certain age periods are so mixed up together in the volume referred to as to render the work of the Census Office comparatively useless as far as the study of medicine is concerned, and this has been done, so we are told, to give a broader and therefore more secure basis for the calculation of rates! Let us illustrate this by reference to some cause of death which will presently be discussed. *Childbirth* (Metria and Puerperal Fever), according to Dr. Farr, caused among *females* in the registration district of Carlisle, during 1851–1860, 78 deaths, which in the mean *female* population at that period of 22,487 in that district amounted to 3·46 deaths from this cause annually to every 10,000 *females* living; in the next decennial period, 1861–70, there occurred 85 deaths amongst the increased population of 24,021 *females*, which equalled a death-rate to every 10,000 females living of 3·53.

[1] This paragraph has been already quoted, but I repeat it here for the convenience of the reader, and for other obvious reasons, so also have I repeated another passage below.

In 1870-80 apparently a sudden change—the annual death-rate from *Childbirth and Puerperal Fever* (Metria) in Carlisle, according to the present Registrar General, amounted only to 2·10, although there had been more deaths, 108, from this cause amongst a mean female population of 25,997 than had ever occurred before.

The paragraph quoted above contains this anomaly. The data that were all-sufficient for Dr. Farr's model Reports have been found not good enough for his successor, who has discovered that the female populations in the districts are not adequate for estimating the death-rates from *Childbirth*, and he therefore supplements them with those of males "to give a broader and therefore more secure basis for the calculation of rates." Garrison towns therefore, where there is necessarily a preponderance of males among the population, would afford the more accurate death-rates from Childbirth, as in such towns the male element would help to broaden the basis for calculation, from the drummer-boy to the general, according to the lines of the passage quoted above.

In the case of Carlisle, the present Registrar General, instead of calculating the death-rate from Childbirth as Dr. Farr had done before him, from the mean female population 25,997, which would have given an annual death-rate of 4·15 to every 10,000 females living, has so mixed up the 23,696 males with the females as to vitiate the Carlisle death-rate, and in a similar manner the whole of the 630 tables in his defective report.

Then, again, the statement that all this was done to meet the practical requirements of the Medical Department of the Local Government Board, is contradicted not only by that department, but carries a contradiction on its very face to any one who knows anything about the requirements of Medical Officers of Health.

True, the medical officers may have said to the Registrar General,—"Send us as early notice as possible of the registra-

tion of any contagious or infectious disease; particulars with regard to sex are not necessary—we merely want the facts of the disease having shown itself somewhere." In the emergency this is all that would be required; it matters not to the Medical Officer of Health whether small pox or any other such disease have attacked a male or female. When, however, the histories of these outbreaks are recorded, and the facts as to age and sex ascertained, then the fullest particulars are always required. If we look at the date of the above Supplement we shall find that it was published at least five years after the last recorded death, and fifteen after the first. It will be hard to make people believe that the Medical Officer of the Local Government Board looks for instant aid from a five-year-old report; he does however, in ascertaining the histories of certain diseases, require such reports as Dr. Farr published, in which he found all ready to hand for his investigation; but certainly when investigating an outbreak of puerperal fever in a district he would not require to have the deaths from this cause so inextricably mixed up with the male population as to render it impossible for him to complete his work without overhauling all the registers of deaths in the District Registrar's office, tabulating them according to sex and age, and then separating the sexes according to the Census Reports. All this work was well done in Dr. Farr's time by his staff, and the result was the two model Supplements. The same work had been done in the Census and General Register Office up to the resignation of Dr. Farr, but in passing through the present Registrar General's hands the males became mixed with the females, and confusion resulted.

The General Death-Rate.

The above table gives at a glance the death-rates among males and females for each district in Cumberland, Westmorland and the Lake District, during the twenty years 1851–1870; a fifth column has been added, but as it contains the

death-rates after the sexes have been mixed, it will only be referred to when whole populations are under discussion.

The death-rates are taken as expressions of the healthiness or unhealthiness of the country taken as a whole, and to a certain extent are useful in this respect, but their great value rests on the help they afford in the investigation of special diseases. A death-rate, like a mean temperature, has to be analysed before it can yield the information we require, for, like a "mean temperature," it may be made up of very diverse factors.

The Cumbrian Area.—It will be seen that, during the three decenniads, in Cumberland, Westmorland, and the Lake part of Lancashire, the mean death-rates among *males* and *females* in the counties of *Cumberland* and *Westmorland* were *below* that of England and Wales to the following extent, thus :—

1851–60—Males	...	38·0;	Females	...	28·7
1861–70— ,,	...	41·6;	,,	...	21·2
1871–80— ,,	...	24·2;	,,	...	10·8

to every 10,000 living, and in the Ulverstone part of Lancashire as follows :—

1851–60—Males	...	30·5;	Females	...	12·3
1861–70— ,,	...	12·3;	,,	...	10·1
1871–80—Report defective, sexes mixed.					

It may therefore be said that this large and important area had, during the twenty years 1851–1870, a lower mortality than England and Wales as a whole, to the extent of 35·6 males and 22·9 females less to every 10,000 of each sex living.

Principal Fluctuation in Death-Rates.—There can be no doubt that the principal causes in the fluctuations in the death-rates of a country are the diseases classed under the heading "*Zymotic*," which, up to the present date, include *Small Pox*, *Measles*, *Scarlet Fever*, *Diphtheria*, *Whooping Cough*, *Typhus*, *Enteric Fever*, *Simple continued Fever*, *Puer-*

peral Fever, *Diarrhœa and Dysentery*, and *Cholera.* Omitting *puerperal fever*, these diseases were the causes of 22·29 per cent. of all the deaths during 1851–1860; 21·25 during 1861–70, and 15·89 during 1871–1880.

Dr. Farr, in his second Supplement, remarks on the name of these diseases, that "*leavens*" have been long known to be capable of reproducing themselves in a *suitable medium;* and from this analogy the zymotic class of diseases is named. The seeds of these diseases enter the body by inoculation, by contact, by ingestion, and by inhalation. Since this term was first applied to the above diseases, investigations have resulted in augmenting the number of diseases that originate in the parasitism of organisms low in the scale of the vegetable kingdom. Professor Tyndall has shown, says Dr. Farr, in his elegant experiments how the air carries dust, and also the *zymotic* particles (zymads) of small pox, scarlet fever, diphtheria, measles, whooping cough, typhus, and plague in the atmosphere that surrounds the sick: in other cases it carries the widely diffused elements that induce *influenza, marsh fevers, neuralgia and rheumatism.*

These zymads, the same author remarks, are attacked in many ways; but in the first rank of their enemies he places "fresh air."[1]

Since the above diseases were grouped others have been found to possess claims for inclusion within the same class, one of which is more destructive than any of them—*Phthisis*, which alone in the thirty years 1851–1880, killed more than a million and a half males and females in England and Wales (1,553,547), or nearly 20 per cent. of the whole number who died during that period, without reckoning those that had succumbed to *Scrofula*, *Tabes*, and *Hydrocephalus.* On March 24th, 1882, Dr. Koch announced the fact that he had discovered not merely a constant concomitant of the tuberculous

[1] *Supplement to the 35th Annual Report of the Registrar General.* 1875, p. lxv.

process, but its cause, and had thereby for the first time given a complete proof of the existence of the *bacillus tuberculosis.* Koch had made his first great discovery (Burdon-Sanderson) of the mode of growing the *bacillus anthracis outside* of the living body in 1876.

Since then a long list of discoveries has been added, each throwing light on the first and guiding future research.

It was Pasteur who first demonstrated that *ferments are living things.*

The organisms connected with specific diseases have been recognised as belonging to the vegetable kingdom, *small plants* (μικρός = small, and φυτόν = a plant), microscopic fungi, in fact.

The causes of death named above under the head "Zymotic Diseases," have only been grouped together to show the enormous influence they have on the death-rate. Each, however, will have to be studied separately in the future, as each plant and each animal has to be studied. Besides, these investigations to be of use must not be limited to our own country; the soils of river-banks and their deltas, natural lagoons, marshes, seasonally flooded areas; their vegetation, and the forms of disease of natives and immigrants, all must be laid under contribution, and will yield abundant material, as the writings of our medical brethren of the early part of this century, who were connected either with the navy or the mercantile marine, testify. In fact, upon the records of such observers was based Dr. Keith Johnston's well-known Atlas of Disease Distribution, which still does good service, as it is an admirable picture of the work done in this way by the medical observers of a past age.

At present we have only to deal with the facts as they present themselves to us, and reap what advantage we can from the knowledge derived from their study.

General Health. Death-Rates from "All Causes," at "All Ages."—Whilst reading the brief notes under this and the

following headings, it will be well to refer from time to time to the contour map, in order to refresh our memory with regard to the physical geography of the several districts, their accessibility to the prevailing winds, their general aspects, and other well-pronounced features which have been abundantly shown to have a marked effect upon health.

General Health in the Cumbrian Area.—The death-rates among males and females during the twenty years 1851–1870, can be studied in the above table, which has added to it the mixed death-rates for 1871–80.

The districts stand in the following order, according to the death-rates, as in the scale on the maps, those having the highest mortality are above, and the lowest below. The mean mixed death-rate for England and Wales during the twenty years (1851–70) being 223·1, and during 1871–1880, to every 10,000 males and females living, 213·0; the mean for the thirty years (1851–1880) being 219·7, which may be reckoned in round numbers at 220.

The mixed death-rates from "All Causes" in the thirteen Registration Districts during the thirty years 1851–70 *and* 1871–80 *compared.*

1851–70.		1871–80.	
Whitehaven ...	238·2	Whitehaven ...	243·2
Carlisle ...	235·5	Ulverstone ...	236·2
Cockermouth ...	227·3	Carlisle ...	231·6
Alston	205·1	Cockermouth ...	210·8
Ulverstone ...	203·8	Alston ...	198·6
Wigton	194·4	Longtown ...	196·0
Penrith ...	189·4	Wigton ...	192·3
Kendal	185·4	Penrith ...	186·7
West Ward ...	182·9	East Ward ...	186·7
Longtown ...	180·9	Brampton ...	182·4
Brampton ...	177·7	Bootle	179·2
Bootle	171·2	Kendal ...	176·4
East Ward ...	169·1	West Ward ...	163·0

General Health and Local Climates.—The thirteen districts of the Cumbrian Lake area may be naturally grouped according to the facilities they present to the different winds that blow from the sea.

The contour map shows us at once that, however apparently sheltered this district may be in some places, there is not one district out of the thirteen but what can be more or less air-flushed. Unlike many areas in the south of England, there are really no thoroughly pent-in, thickly populated valley systems, through which prevailing winds can obtain no access, such as have been described in an earlier chapter. Let the reader follow well the courses of the dark and light blue inter-contour spaces on the contour map, and a good general idea will be obtained of the physical characters of the different groups in relation to the several winds blowing from the sea.

Groups of Districts.

I. *Southerly Group* (S.), *Kendal*, *Ulverstone* and *Bootle*.

II. *South-Westerly* (S.W.a.), *Whitehaven* and *Cockermouth*; (S.W.b.) *Longtown* and *Brampton*.

III. *North-Westerly* (N.W.), *Wigton*, *Carlisle*, *Penrith*, *West Ward*, *East Ward*.

IV. *Northerly* (N.), *Alston*.

The scale for a map showing the geographical distribution of general mortality would be the following :—

Darkest Blue	+ + +	260	and upwards		Annually to every 10,000 living, 1851–1870.
Darker Blue	+ +	240	...	260	
Blue ...	+	220	...	240	
Red ...	−	200	...	220	
Darker Red	− −	180	...	200	
Darkest Red	− − −	and below		180	

Groups.	Districts.	Death-Rates.	Means.
S. (pp. 188–189)	Kendal	185·4	S. 186·8 — —
	Ulverstone	203·8	
	Bootle	171·2	
S.W.a. (pp. 185–187)	Whitehaven	238·2	S.W.a. 232·7 +
	Cockermouth	227·3	
S.W.b. (pp. 183–184)	Longtown	180·9	S.W.b. 179·3 — — —
	Brampton	177·7	
N.W. (pp. 184–185, 180 and 190)	Wigton	194·4	N.W. 194·6 — —
	Carlisle	235·5	
	Penrith	189·4	
	West Ward	182·9	
	East Ward	169·1	
N. (p. 180)	Alston	205·1	N. 205·1 —

It will be seen from the above table that of the five groups only one (S.W.a.) has a mean death-rate above the average of England and Wales—the one containing Whitehaven and Cockermouth; besides which Carlisle is the only district in the other groups that has a mortality above the average. These exceptions will be referred to again. The *lowest* mortality group is the one composed of Longtown and Brampton. Both these districts are well open to the S.-W. winds from the Solway Firth; coincident with which we shall find a *low* death-rate from Heart Disease, and a high death-rate from Phthisis among females.

The diseases that affect the general death-rates the most seriously are those described as zymotic, already referred to, as in some instances they constitute 20 or 25 per cent. of the whole annual mortality even in this healthy area. The three districts named owe their higher death-rates principally to these diseases and not solely to climatic causes.

But all zymotic diseases are more or less influenced by climates and seasons; in fact, if, as seems to be the case, they are the outcome of the vigorous growth of microphytic organisms in the blood and other living tissues of animals, it is but reasonable to expect that they should be amenable to the influence of climates and seasons. The microphytes of several of the zymotic diseases have ever been exotic, and have depended for their transmission entirely to contact with the person or with the air that has been in contact. Typhoid is indigenous, and so are some other fevers. Cholera is a good specimen of an exotic; so long as it can pass from one fertile soil to another of equal temperature, that of the blood, it will continue to thrive and kill; but it soon declines and dies out when it is no longer surrounded by as rich a soil and as high a temperature as those amidst which it was ushered into life on the banks of the Ganges.

Whether exotic or indigenous, all the organisms whence zymotic diseases spring unfortunately find conservatories in the filthy soil in and around our habitations, where they can temporarily conceal themselves and lie *perdus* until chance gives them an opportunity of invading our bodies. If we were to colour a map of the general death-rate according to the table above, we should find the above three districts distinguished by *blue*.

Carlisle, Whitehaven and Cockermouth. Thus these districts containing large urban populations had their death-rates during 1851–70 markedly increased by zymotic diseases in the following manner.

	All causes.		Zymotics.
Carlisle	235·5	less	59·5 = 186·0
Cockermouth	227·3	,,	51·2 = 176·1
Whitehaven	238·2	,,	55·3 = 182·9

Such facts as these, however, are too well known to require discussion.

Even although zymotic diseases have seriously affected the

death-rates in this area, it will be seen by this table, and still more clearly by a map coloured in accordance with the scale, that the general configuration of the country has contributed very much to the comparatively low death-rate from all causes and at all ages.

Section IV.—Stomach and Liver Diseases; Diseases of the Kidneys; Childbirth and Metria.

Stomach and Liver Diseases—England and Wales—Cumbrian and Lake area—Table of Death-rates—Diseases of the Kidneys—England and Wales—Cumberland and Lake Area—Table of Death-rates—Males and Females—Difference—Childbirth and Metria—England and Wales—Cumbrian and Lake District—Table of Death-rates—Childbirth and Metria—Table of Zymotic Diseases for the three Decenniads.

I will now briefly discuss the distribution of the following causes of death during the past twenty years, 1851–1870.

I. *Stomach and Liver Diseases;* II. *Diseases of the Kidneys;* and, III. *Childbirth and Metria.*

Diseases of Stomach and Liver.

That the digestive organs are influenced by local climates has always been acknowledged, but whether the stomach and liver are subject to the same influences and in an equal degree, is a question that certainly will not be solved by grouping these two organs together. We know generally that a well air-flushed country has a greater chance of a *low* death-rate generally than one honey-combed with sleepy hollows; we know too, without statistics, that these latter valley-systems as a rule are adverse to that high state of the general tone of the body so essential to the health of the digestive organs, the chief among which are the stomach and liver.

During the twenty years 1851–1870, there died in England and Wales 197,398 males and 203,128 females from diseases of

the stomach and liver, amounting to a death-rate annually among *males* 10·02, and *females* 9·81.

In the Cumbrian and Lake Area, we find the *lowest* mortality from these diseases among *males,* in *Longtown,* 9·19 ; *East Ward,* 9·14; *Bootle,* 7·14 ; and *Whitehaven,* 9·41. All the other nine districts would be coloured *blue,* indicating above the average, the highest being that of *Alston,* 14·42.

Amongst *females all* the districts have a death-rate *below* the average, except the belt of districts that stretches from Northumberland to the sea — to the north of the great *Transverse Ridge* and under its lee as regards the southerly and south-westerly winds. This belt consists of *Alston,* 19·38; *Penrith,* 11·90 ; *Cockermouth,* 11·46 ; and West Ward, 10·24.

	M.	F.		M.	F.
Alston ...	14·42 ...	19.38	Whitehaven	9·41 ...	10·07
Penrith ...	10·98 ...	11·90	Bootle ...	7·41 ...	4·62
Brampton ...	10·49 ...	9·91	East Ward ...	9·14 ...	9·22
Longton ...	9·19 ...	9·17	West Ward	11·23 ...	10·24
Carlisle ...	10·51 ...	9·74	Kendal ...	10·98 ...	10·10
Wigton ...	11·96 ...	8·36	Ulverston ...	11·83 ...	10·44
Cockermouth	10·90 ...	11·46			

We shall see when discussing diseases of the heart and the circulatory organs, that they have a similar death-rate to the diseases under discussion, and as a rule they are to be found prevailing among communities located where the more tonic winds are shut out and the more used-up air is shut in. The type, however, of the Geographical Distribution of Diseases of the Liver and Stomach is not pronounced; but both these organs throughout life are highly sensitive to the quality of local climates, and climatic influences are often so stamped upon them as to reduce their power of resisting disease in a remarkable manner, and considering how these organs are abused and over-burthened it is marvellous to think how they escape so frequently. The deaths

among females will prove more instructive than those among the other sex.

Taken as a whole, the diseases of the digestive organs have nothing specific about them, so will be found to thrive in Great Britain, where the climate is relaxing, as in pent-up valley-systems, and ill-adapted to fortify the body against the assaults of disease and injurious meat and drink.

Diseases of the Kidneys.

During the twenty years 1851–70, 473,236 males and 31,216 females died from this group of causes in England and Wales; the death-rate being among males 3·71, and among females 1·50 to every 10,000 living, or less than half. These organs are subject to all kinds of influences; they are most sensitive to climatic impressions, and are far from being impregnable to the micro-organisms out of which spring specific diseases. The kidneys are generally very ill-used organs. They are acutely impressionable to what takes place at the surface of the skin, and hence are affected by climatic changes, of which they are especially sensitive during depression succeeding over-stimulation, the result of alcohol drinking or the reaction brought about by resisting specific forms of disease. In this country, chills or long-continued cold upon the surface of the body are the most frequent exciters of kidney disorder when weakened by other causes.

In our area the distribution of mortality is as follows :—

	M.	F.		M.	F.
Alston ...	2·37 ...	2·36	Whitehaven	2·59 ...	1·66
Penrith ...	3·92 ...	1·76	Bootle ...	2·18 ...	·79
Brampton ...	3·62 ...	1·48	East Ward ...	2·53 ...	·48
Longtown ...	2·66 ...	0·52	West Ward	2·51 ...	1·89
Carlisle ...	4·88 ...	2·15	Kendal ...	3·91 ...	1·45
Wigton ...	2·88 ...	0·97	Ulverston ...	2·43 ...	1·08
Cockermouth	3·96 ...	1·64			

Among *males* during the decenniad 1851–1870, *Penrith,*

Carlisle, *Cockermouth*, and *Kendal* had a death-rate above the average, but in no instance was it pronounced. Among *females* the death-rate exceeded the national average in *Alston*, *Penrith*, *Carlisle*, *Cockermouth*, *Whitehaven*, and *West Ward*. So that if the standard were adopted for *males* of 4 and 2 for females to every 10,000 living, only *one* district Carlisle (4·88) would be coloured *blue* on the map for *males*, and two on the map for *females: Alston*, 2·36, and *Carlisle*, 2·15. From this we may conclude that the several kinds of kidney diseases included in this group, either are not prevalent in this area, or if they are the climate cannot be obnoxious to any great extent to those suffering from them.

Childbirth and Metria.

This group unfortunately increases in importance almost in the direct ratio of the existence of those soils that offer the greatest temptation to the soil-seeking pathogens of specific diseases, whence they are easily and speedily transferred to the still more genial soil offered by the exposed living structures of recently delivered women.

The number of women living between 15 and 55 years, the ordinary limits of child-bearing, exceeds the half of the whole female population in England and Wales.

1851–1860. Females at all ages, 9,718,174. Women between 15 and 55 years, 5,308,376.

1861–1870. Females at all ages, 10,971,649. Women between 15 and 55 years, 5,943,969.

During the twenty years 1851–1870, there died in England and Wales from this group of causes 66,310, which equalled a death-rate to every 10,000 women living between 15 and 55 years of 5·89. If we take 6·0 as the standard death-rate, we shall obtain some idea of the distribution of these causes within our area.

During the same period this group caused in the 13 regis-

tration districts 958 deaths among women between 15 and 55 years, equalling a death-rate of 5·68, or one a little below that of England and Wales.

	Women.		Women.
Alston	5·29	Whitehaven ...	6·50
Penrith	4·56	Bootle	6·31
Brampton	3·43	East Ward	5·32
Longtown	7·13	West Ward ...	4·96
Carlisle	6·40	Kendal	4·92
Wigton	5·35	Ulverston	7·39
Cockermouth ...	6·39	England and Wales	5·89

In the above statistics the deaths from puerperal fever were included under the head Childbirth and Metria, and although in the Supplement for 1871–80 "*puerperal fever* and *childbirth*" are tabulated separately, the deaths from these causes are designedly mixed up with the *male* populations of the districts, "to give a broader and therefore more secure basis for the calculation of rates" from those causes of death among the *female* population.

In the above list Longtown (7·13) takes the second place, Ulverston being the highest (7·39).

It would be useless to venture to suggest a reason for the distribution which the above death-rates indicate; I shall therefore conclude this section by giving the death-rates from zymotic diseases among the mixed population of the districts during the thirty years 1851–80, as tables of reference.

Zymotic Diseases.

Districts.	1851–60.	1861–70.	1871–80.
Alston	29·19	41·07	21·93
Penrith	26·57	23·48	14·73
Brampton	+53·44	26·07	19·26
Longtown	26·81	24·24	21·52
Carlisle	48·92	+50·12	+35·83
Wigton	29·40	28·33	24·06

DISEASES,

RT DISEASE

LES & FEMALES)

1851—1870.

MAPS OF THE GEOGRAPHICAL DISTRIBUTION OF DISEASES,

IN THE ENGLISH LAKE DISTRICT,

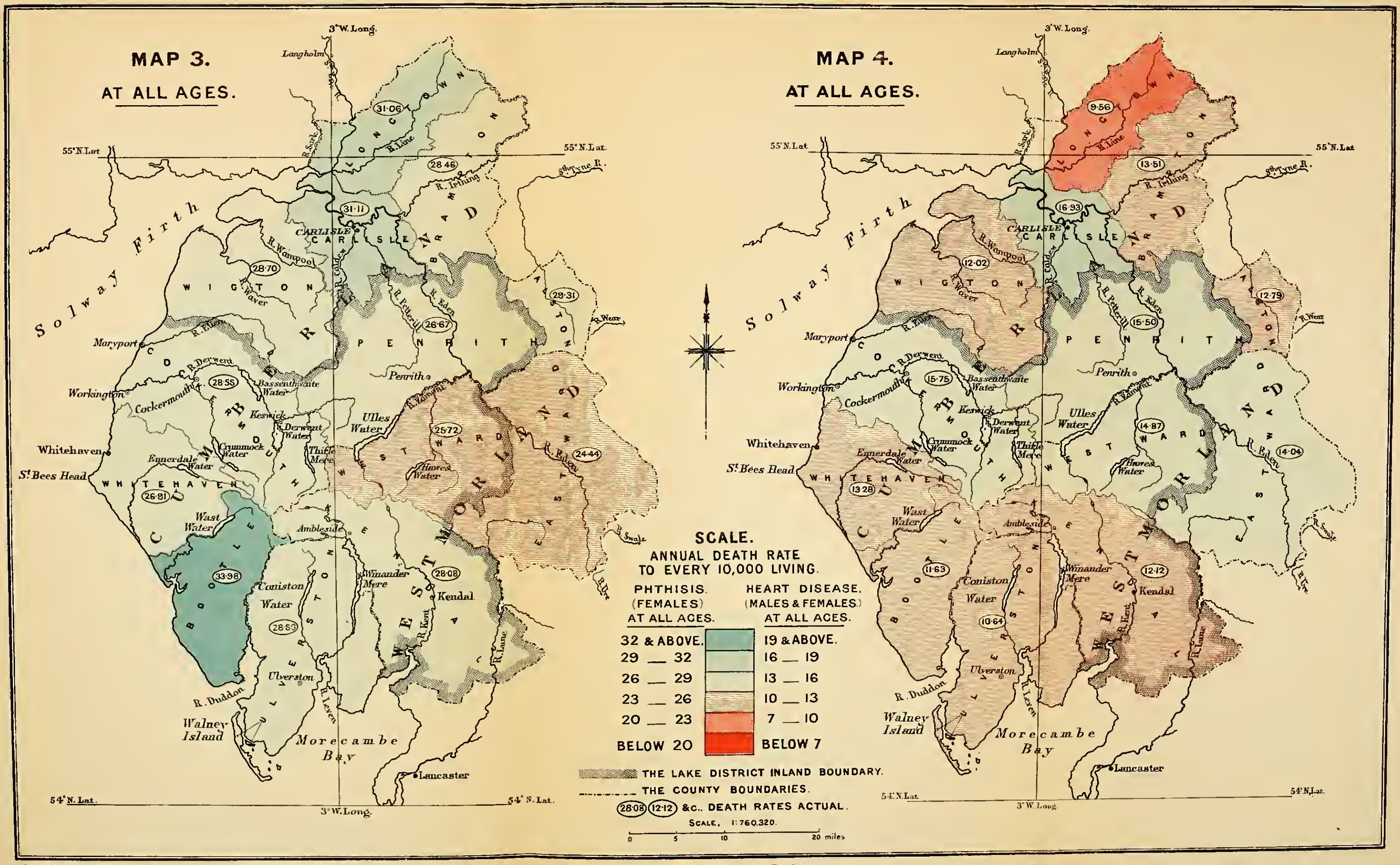
CUMBERLAND AND WESTMORLAND,

1851——1870.

PHTHISIS (FEMALES) 1851—1870.

HEART DISEASE (MALES & FEMALES) 1851—1870.

BY ALFRED HAVILAND, M.R.C.S.E., &c.



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Districts.	1851–60.	1861–70.	1871–80.
Cockermouth ...	48·54	+53·89	+37·41
Whitehaven	+50·63	+60·03	+43·25
Bootle	21·36	27·35	33·15
East Ward	26·76	18·73	18·75
West Ward	24·77	21·56	15·53
Kendal	37·95	25·05	17·22
Ulverston	40·21	41·64	+46·60
England and Wales ...	49·36	47·63	34·00

+ Indicates *above* the national standard.

Each of the specific diseases should be studied separately, as the organisms that produce them differ as widely from each other as an aconite from a hellebore, or a limestone-loving from a clay-loving plant.

Section V.—Phthisis and Heart Disease.

Description of Phthisis Map—Mortality in England and Wales—Death-rates among Males and Females in Cumberland and Lake District—Males and Females, 1861–1870—The Great Transverse Ridge and the Windward and Leeward Valley Systems—Contour Map—Effect of Strong Winds on the Phthisical—Dampness of Soil—Bowditch—Buchanan—Whitaker—Description of the Heart Disease Map—High and Low Mortality Districts—The Transverse Ridge—Difference in Mortality from Heart Disease on the North and South Sides of the Transverse Ridge—Table of Death-rates.

We now resume the Geographical Distribution of *Phthisis* and *Heart Disease*, and in doing so the reader should refer to the pages where these causes of death are discussed in Chapter II.[1]

Phthisis.

Description of the Map.—When I first investigated the dis-

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[1] *Phthisis*, pp. 29 and 39 et seq.; Heart Disease, pp. 33 et seq.

tribution of this disease (1868), the original map was constructed to show it throughout England and Wales among females, as a companion map to the one of the Distribution of Cancer among that sex.

During the decenniad 1851–1860, the average death-rate for England and Wales among *females* was 27·74 to every 10,000 living; during 1861–70 it had declined to 24·83. In my first map the death-rates in our area were indicated according to the higher scale, the standard being 28. In the present map the colouring has been regulated by the mean of the two decenniads, 26·20 (standard 26), so that the local death-rates from Phthisis among females are measured by a lower standard; and if they have not declined in the same ratio as they have done throughout the country, the colouring of the map will at once make this apparent.

In the former map there were seven districts coloured *blue* (high mortality), and six *red* (low).

In the present map coloured according to the lower mean standard (26), there are only *two* districts coloured *red* (low), whilst the eleven others are coloured *blue* (high).

The reader is now well acquainted with the configuration of the area, and understands how it is that the sea-winds exert such a powerful influence throughout its valley system. Bearing in mind what has already been said with regard to the effect of the *force* of the wind increasing the mortality from *Phthisis*, the high mortality all around the Cumberland and Lake District coast, as indicated by the varying shades of *blue*, is in accordance with that experience; the two low-mortality (*red*) districts of East Ward and West Ward are also in harmony with what has been found when consumptive communities are sheltered from the direct force of the sea-winds.

Statistics.—During the period 1851–1870, the deaths of 542,085 females were registered in England and Wales as having been caused by *Phthisis* (Consumption, or Pulmonary

Tuberculosis), which amounted among that sex to an annual death-rate of 26·20 to every 10,000 living (standard 26).

During the same period the number of deaths among males from the same cause reached 496,263, and a death-rate slightly lower, namely 25·19.

In Cumberland and the Lake District the death-rates were as follows:—

1851–1870.

Districts.	Males.	Females.
Alston	24·25	29·31
Penrith	21·92	26·67
Brampton	28·42	28·46
Longtown	24·91	31·06
Carlisle	30·39	31·11
Wigton	24·24	28·70
Cockermouth	23·05	28·55
Whitehaven	22·62	26·91
Bootle	19·04	33·98
East Ward	20·01	24·44
West Ward	23·19	25·72
Kendal	25·35	28·08
Ulverston	22·55	28·56
England and Wales	25·19	26·20

From the time that the first map of the Distribution of Heart Disease and Diseases of the Circulatory Organs was constructed and construed, it has always served as a guide to the well and ill ventilated districts of England. How it acts so has already been indicated (p. 33).

In the Lake District the Great Transverse Ridge, so frequently referred to, acts as a natural barrier between two sets of districts differing widely as regards their direct exposure to the strong prevailing winds from the South to West by South-West. On the *windward*, or the side exposed to

these winds, are the four districts of Kendal, Ulverston, Bootle, and Whitehaven; and on the *leeward*, or the side sheltered from those winds, lie East Ward, West Ward, Penrith, and Cockermouth.

It will be seen, in the map illustrating the Distribution of Phthisis among females, that the *windward* districts are coloured *blue*, indicating a mortality *above* the average, each district from east to west having the following death-rates respectively:—28·08, 28·56, 33·98, and 26·91, mean 29·38. On the *leeward*, or sheltered side of the ridge, the districts named above from east to west have the following death-rates:—24·44, 25·72, 26·67, and 28·55, mean 26·34.

The most exposed districts on the *windward* side, Bootle and Ulverston, had a mean death-rate of 31·27; whilst on the *leeward* side in the most protected districts, West Ward and East Ward, the mean death-rate only amounted to 25·18.

These figures must be taken as the general result of the statistics for the 20 years 1851–1870. In districts having small populations the death-rates fluctuate; a large number of consumptive males or females may be killed off in two consecutive decenniads, the result being a reduced total of possible victims remaining in the succeeding period: for instance, take the Bootle district, in which during 1851–60 the annual death-rate was 31·69 among females; in 1861–70 it rose to 35·89; but in 1871–80 dropped to 19·50.[1] In 1851–60 West Ward had the high death-rate of 30·33, and was coloured *blue* in the first edition of this map; in 1861–70 the death-rate was reduced to 21·58; but rose to 22·40 in 1871–80.

In grouping the districts, therefore, we should take the entire number of deaths and the populations among which they occur, otherwise the death-rate in a small population might influence unduly that of a more important district.

[1] Mr. Lowe's Returns, 1871–1880.

On the other hand we must be careful not to include within a protected group a district that is well exposed to the sea breezes, as Cockermouth, which was shown at page 47 to have a coastal and exposed population equal to 54·6 per cent.; this district should therefore be eliminated, and if so, Whitehaven, with its 48·5 per cent. of coastal population, should be withdrawn, so as to keep a just balance. Thus reduced, the female populations occupying the windward and leeward flanks of the Transverse Ridge (as regards the powerful prevailing winds from south to west), are found to have had 3,537 deaths from Phthisis during the twenty years 1851–70, of which 2,372 were registered on the *windward side* among a mean population of 41,247 females, or equal to a death-rate of 28·38 to every 10,000 females living; whilst on the *leeward* or protected side, in a mean population of 22,553 females, there were only 1,165 deaths, or at the annual rate of 25·82. This excess of deaths (2·56) among consumptives, small as it may appear, becomes an important item in the general death-rate from all causes, and a serious figure in the course of twenty years. An excess of 2½ females to every 10,000 living on the windward side cost that mean population of 41,247 annually, in round numbers, at least 10 lives, or 200 in the whole period of twenty years, that the more protected would have preserved, and perhaps have given a chance of outliving their inherited or acquired disease.

If we now examine the other districts we shall find those characterized by the freest access to strong winds, such as Longtown, coloured in the darker *blue*, indicating a mortality between 29 and 32, but having in reality one of 31·06, or 5·24 above that of the *leeward* group (25·82). In fact, if we examine the contour map in conjunction with that of Phthisis (females), we shall find that, owing to the configuration of the valley system of the whole area, the death-rates have a tendency to increase from the central and more protected districts to the peripheral or coastal and more exposed.

Alston is not only exposed in consequence of its elevation, but through the valley of the South Tyne, which gives access to the northerly winds.

Conclusion.—Whatever may be the cause of this higher death-rate from Phthisis among females in districts exposed to the direct force of the wind, the fact remains, and in practice should be made use of. It can hardly be supposed that the strong sea-breezes bring the cause of *pulmonary tuberculosis* with them (*bacillus tuberculosis*); it is far more probable that the irritating qualities of the strong atmospheric currents, more or less ozoniferous, produce pulmonary catarrh, and thus in the untainted, but susceptible, prepare the lung for the bacillus, and in the tainted expedite the process of destruction, which had been commenced by the pathogenic parasite.

The contour map will direct the practitioner where the needed protection from these irritating winds can with certainty be found.

We have just been discussing the effect of strong winds on persons tainted in their lungs with disease, the result of the parasite known as *bacillus tuberculosis*; and we have been able to define the localities where these currents have freest access, by noting the districts where the greatest number of females have died from Phthisis during the twenty years 1851–1870. These forcible winds, although not the cause of the disease, are accessories, as they either prepare the way for the reception of the bacillus by causing local pulmonary catarrh in the hitherto unaffected, or finding the diseased ready to hand, give them their *coup de grâce.* There are many countries in the North of Europe where much fiercer winds prevail, but where there are no deaths from Phthisis, simply because there are none tainted by the tuberculous parasite to be killed off by them. And even in our country we have found great changes occurring in districts as regards the number of phthisically tainted inhabitants. We have met

with districts well known for the number of phthisical cases, that have lost that character for many years, on account of the reduction of the number of cases; during which time it had been remarked that an increased number of deaths from cancer had appeared in the locality. Unfortunately, throughout Great Britain there are no communities untainted by tuberculosis; and hitherto, wherever they are exposed to the full force of the prevailing winds, there the localities have been marked by the heaviest death-rates. The death-rates from *Phthisis* have declined of late years; but as we do not understand the cause of this decline, so are we uncertain how soon the disease-wave may rise from trough to crest. The late Dr. Bowditch's investigations led him to the conclusion that *dampness of soil* had much to do with the high mortality from Phthisis in clayey localities. Similar investigations were carried out in the South-East of England by Sir George Buchanan and Mr. Whitaker, but these enquirers did not take into account the effect of aspect. My own observations in the same part of England brought out the fact that in the low-lying damp, but *sheltered* areas, the mortality was *low*, whilst the same damp clayey stratum *elevated* and *exposed* to the full force of the winds had a *high* death-rate.

Heart Disease and Diseases of the Circulatory Organs.

If forcible winds spread havoc among the consumptive, we shall presently see that they have also a compensating influence in preventing diseases, and reducing the death-rates wherever they can penetrate, so that in describing the map illustrating the distribution of this group of diseases, we shall have to go over much of the same ground that has just occupied our attention.

Our experience will, however, be reversed; for we shall find in the districts most exposed to the prevailing winds the *lowest* death-rates, and in the sheltered districts the *highest*.

The reader is referred to a former chapter (p. 33) for a general introduction to the distribution of these causes of death.

Description of the Heart Disease Map.

Bearing well in mind what has been said when discussing the distribution of *Phthisis* among females, and the remarks just made, the reader's attention is directed to the following facts :—

1. *Low-mortality districts coloured in shades of red.*—The four districts exposed to the direct influences of the prevailing southerly and south-westerly winds, are Kendal, Ulverston, Bootle, and Whitehaven. These are well air-flushed districts; and coincident with this fact is the other, that they have an individual and mean annual mortality below the average of England and Wales, 13 to every 10,000 males and females living.

This group south or windward of the Transverse Ridge has an annual mortality of only 11·91, and is coloured light *red*. The *Wigton* district, well open to the north-west winds, with extensive flat foreshores, is also coloured *red*, and having the death-rate 12·02. *Longtown* and *Brampton* are both coloured *red*, and have been described as well air-flushed by the south-westerly winds, which were found to be so obnoxious to the consumptive, amongst whom it caused a high mortality, especially in the Longtown district: in the *Phthisis* map it is seen to be coloured *dark blue*, and in the Heart Disease map is *dark red*.

The district of *Alston*, well air-flushed on account of its elevation and its being open through the valley of the South Tyne, is the remaining low-mortality district.

2. *High-mortality districts.*—It will be noticed that all these lie to the north of the Great Transverse Ridge. The districts immediately to the leeward (as regards the southerly and south-westerly winds) are East Ward, West Ward, Penrith and

Cockermouth; they are coloured *blue*, and have, as a group, a mean annual mortality of 15·04 to every 10,000 living.

The difference in the annual mortality during the twenty years 1851–70 between the districts on each side of the Great Transverse Ridge was as follows :—

Four districts North of Transverse Ridge	....	15·04
,, ,, South ,, ,,	....	11·91
Difference	....	3·13

Table of Death-rates,
1851–1870.
(Males and Females.)

Alston	....	12·79	Whitehaven	....	13·28
Penrith....	....	15·50	Bootle	....	11·63
Brampton	....	13·51	East Ward	....	14·04
Longtown	....	9·56	West Ward	....	14·87
Carlisle....	....	16·93	Kendal	....	12·12
Wigton....	....	12·02	Ulverston	....	10·64
Cockermouth	....	15·75	England and Wales		13·00

Such are the facts connected with the distribution of Heart Disease in the Cumberland and the English Lake District.

Section VI.

Review of Coincident Facts connected with Geology, Physical Configuration, etc.—Hydrography—Meteorology—Local Climatology.

Before concluding, I will draw attention to some of the chief facts that have been discussed in this chapter on Disease Distribution.

Geological.—In the distribution of *Cancer* among both males and females, it has been shown (1) that the districts characterized by a more or less limestony rock have a *low* mortality, and that this fact had been recorded for the twenty years 1851–70; and (2) that the districts subject to seasonal

river-floods, and having a soil characterized by *clays*, had during the same period a *high* mortality.

Evidence was adduced that whilst in the Cumbrian and Lake area, the flooded and clayey districts, the *high* mortality was not so great as in many other similar localities in England, the *low* death-rates from cancer were among the lowest in the country.

Physical Configuration.—It has been shown that wherever the land was capable of being thoroughly air-flushed, the death-rates from "*all causes,*" at all ages, were generally the *lowest*, except in the case of Phthisis, and in urban districts, in which bad street and other social insanitary arrangement antagonised the natural advantages derivable from local configuration and local climates; and that the distribution of *zymotic* diseases appeared to be influenced in a similar manner. It has also been shown that the death-rates from *Diseases of the Heart and Circulatory Organs*, were greatly influenced by the configuration of the land; *rising* considerably whenever impediments existed to the free air-flushing of the districts, and *falling* in an equal degree among communities exposed to the thorough air-purging of prevailing winds.

It has been observed that in the former districts the prevalence of heart disease was associated with endemic *rheumatism* either in an acute or chronic form, and that the author had found this association between the prevalence of rheumatism and high mortality from heart disease to obtain throughout Great Britain; fully confirming the experience of the celebrated Dr. David Pitcairn, who was elected Physician to St. Bartholomew's Hospital, 10th February, 1780, and who in one of the earliest courses of lectures on Medicine in that school, pointed out for the first time the relation between *Cardiac Disease and Acute Rheumatism.* It may be here observed that whilst the death-rates from *Heart Disease* in the Cumbrian and Lake District are not excessive, when compared with the mortality from this cause in such counties

as Dorset and Wilts, where they frequently rose during the same period to 19–23 to every 10,000 annually, they yet observe the same rule of distribution as the author has observed throughout Great Britain. Pertinent to the remarks just made, I may mention that whilst this work was going through the press I received a most valuable communication from Dr. William Vawdrey Lush, of Weymouth, Consulting Physician to the Dorset County Hospital, in the form of the statistics of cases of Heart Disease treated at that institution during the decenniad 1881–90, by which he shows that out of 71 histories of Cardiac cases, 37 were associated with Rheumatic Fever, or 52·1 per cent. Dr. Lush in this interesting and elaborate report has included the residences of the patients, so that cases can be traced back to the civil parish and registration district where he or she had been living at the time the disease was contracted. I can only refer *en passant* to Dr. Lush's contribution in the present part, but hope to treat it fully in a subsequent one, in which the distribution of diseases in the county of Dorset will be discussed. The death-rates from Diseases of the Heart and the Circulatory Organs during the twenty years 1851–70, in the county of Dorset, ranged from 12·4 and 12·7 in the well air-flushed districts of Weymouth and Poole respectively, to 18·4 in Dorchester and 19·3 in Beaminster.

It must be remembered that the broad, open ice-carved valleys of the Lake District are widely different from river-valleys of the South of England, where glaciers were unknown even in the Ice Age; the classic Meander was more the type of the river-valleys that open into the English Channel, so that their tortuous courses offered innumerable obstructions to the free passage of sea winds; and moreover the majority of the valleys are not coincident with the courses of either the prevailing winds or the tidal wave but nearly at right angles to them.

In the map of *Phthisis* we saw that the very winds, the

force of which contributed to purge the valleys of the *malaria* which enwrapped the *materies morbi of rheumatism* (whether in microphytic or other form), were fatal to those whose lungs the *bacillus tuberculosis* had invaded and necrosed.

How these strong currents act, as yet remains undiscovered unless the suggestion thrown out (p. 360) prove to be the correct one.

Such are the salient facts that have been treated in these chapters. They are full of suggestions, and in the present state of mental activity there is no fear of their remaining unheeded.

Section VII.

A Brief Summary of results already obtained, and probable Fuller Development of the Investigation considered.

In Chapter VIII. reference has been made to *racial characters*, as lending assistance to the medical practitioner by the bedside or in his consulting room. No conclusions have been drawn as to the effect of dominant characteristics on the history of any of the diseases discussed in this work; but the author has given the interesting facts of Dr. John Beddoe, and Chancellor Richard S. Ferguson, in the hope that in future medical men will note certain physical characters in the clinical histories of their cases, and thus lay the foundation of a more perfect knowledge than we now possess of the relation between racial peculiarities and susceptibility or insusceptibility to certain disease-forms.

I have briefly alluded to the *Wheat-yield* as affected by local climates, and the curious fact that the local climates which conduce to a *light* wheat-yield are associated with a heavy death-roll from heart disease, whilst a *heavy* wheat-yield is invariably found where free ventilation by the prevailing winds secures the *lightest* death-rate from Cardiac and other diseases of the circulatory organs.

The object of this investigation has been to point out to

the medical profession, not only where certain diseases *do thrive*, but where they do not; with the further object of leading others to inquire why this is the case in their own localities. When this inquiry first took place, in 1868, it was not anticipated that so vast a progress in tracing the causes of specific forms of disease was at hand. Nevertheless we find ourselves in full activity in a direction that gives reasonable hopes of discovering why forcible winds should slay the consumptive; why the earth should afford a soil favourable to the culture of some organic form that is at the source of rheumatism and its frequent sequel cardiac disease; and the time may not be far distant when some of the many forms of micro-organisms that swarm in the sodden clay lands after floods, shall be thoroughly examined and their forms and histories known—such investigations being followed by the discovery of those species that are the exciters through their poisons of malignant growths known as cancers; it may also come to pass that we shall find out on what the effect of calcareous soils on these species depend. Search will be made in the deltas and banks of tropical rivers for those organisms which render their *malaria* so fatal to the human race. And finally, it may be accorded to us to discover the means of protecting our bodies against pathogenic organisms which, from the vast abundance and wide distribution, we are unable to destroy before they attack us. We shall then be able to add *Protective* to Preventive and Curative medicine.

In the meantime this investigation has not been without results; for its teaching has pointed out, however imperfectly, where it would be unsafe for the medical man to advise some of his patients to reside. With the *facts* before him, which twenty years' statistics spread over Great Britain have confirmed, no medical man would send

(1) A *consumptive* case to live where he would be subject to the *full force* of prevailing winds.

(2) Or one dreading *rheumatism* and *heart disease* into an unventilated pent-up valley, where the mortality from cardiac affections is high.

(3) Nor would he send the offspring of *cancerous* parents to reside, either for education or earning their livelihood, in low-lying, clayey, flooded districts.

Rather would he advise the *consumptive* to seek well-sheltered, fertile, upland localities where the trees are symmetrical and erect; those suffering from the forms of heart disease associated with *rheumatism* well-ventilated, well-aspected districts, where the wheat-plant thrives and yields plentifully; and those having reason to dread *cancer*, the high dry districts characterized by either *limestone* or *chalk* formations.[1]

As a ready *guide* to the busy medical practitioner, the coloured maps illustrating this work have been devised by the author, to show the facts he has gathered, and to stimulate others to further investigations.

In the preceding chapters I have endeavoured to show how necessary a thorough knowledge of a country is, when studying the natural history of the diseases we are called upon to treat within its limits.

In the next part of this work, which will embrace the Geology, Climatology and Disease-distribution of *The Basin of the Thames*, we shall see repeated many of the typical facts, which characterize the medical geography of the Cumbrian and Lake District, however much they may be modified by differences in the soil, physical configuration of the land, and other climatic factors of that extensive, varied, and interesting area; the careful study of which will still further impress us with the soundness of the apophthegm that enjoins us to know our own country.

[1] See Appendix for a note on Dr. G. Sims Woodhead's "Morton Lecture" on "The Etiology of Cancer," reported in *The British Medical Journal*, May 7, 1892, p. 954.

APPENDIX.

APPENDIX A.

FLORA CALCAREA.

The Flora of the British Limestone and Chalk formations.

The remarkable facts connected with the influence of the Limestone and Chalk rocks on the Medical Geography of Great Britain, and especially on the Geographical Distribution of *Cancer* among females, have induced me to publish a list in this work of the plants that are known to flourish in the soils overlying these formations, in the hope that by doing so the subject will receive further consideration, not only from my medical brethren, but from those who are pursuing the delightful study of Botany. The subjoined list is the one referred to when I brought the subject before the International Geological Congress, held in London in September, 1888,[1] augmented, however, by contributions from the notes of Mr. Joseph A. Martindale, the accomplished botanist of Staveley. This gentleman has most kindly furnished me with a list of over a hundred plants which he has divided into two classes: (1) those that are almost entirely confined to stations on *Limestone;* and (2) those that are more common in the Lake District on that formation than on others.

In the following list all the thirty plants named in Mr. Martindale's first class have been included and are distinguished by an asterisk (*), and the districts in which they

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[1] *Congrès géologique international, Compte Rendu de la Quatrième Session.* Londres, 1888, p. 238. Dulau, 1891.

Medical Press and Circular, "Chalk *v.* Cancer," Sept. 26th and Oct. 10th, 1888, pp. 327, 369, respectively.

have been found are indicated by the three first letters of their names; thus—*Pen.*, *Coc.*, *Whi.*, *Boo.*, *Ulv.*, *Ken.*, and *W. Wa.*, for *Penrith*, *Cockermouth*, *Whitehaven*, *Bootle*, *Ulverstone*, *Kendal*, and *West Ward.* Mr. G. J. Baker, F.R.S., F.L.S., in his "*Flora* of the English Lake District" (Bell & Sons, London), has marked the plants characteristic of the limestone, "xerophilous."

A List of the principal British Plants that are found in Limestony and Chalky districts, and are known to thrive best in such soils.

The following abbreviations are used:—

B. = "*Manual of British Botany, containing the Flowering Plants and Ferns.*" Arranged according to Natural orders by Charles Cardale Babington, M.A., F.R.S., F.L.S., etc., Professor of Botany in the University of Cambridge. Eighth edition, corrected throughout. London: John Van Voorst, Paternoster Row, 1831.

S. = "*British Wild Flowers.*" Illustrated by John E. Sowerby. Described, with an Introduction and a key to the Natural Orders, by C. Pierpoint Johnson. Reissue, to which is now added a Supplement containing 180 Figures of lately discovered Flowering Plants. By John W. Salter, A.L.S., F.G.S.; and the Ferns, Horsetails, and Club-mosses, by John E. Sowerby. London: John Van Voorst, Paternoster Row, 1882.

The numbers following S. apply to pages and Figures.

N.D. = "*The Naturalist's Diary: A Day-book of Meteorology, Phenology, and Rural Biology.*" Arranged and edited by Charles Roberts, F.R.C.S., L.R.C.P., etc. Swan Sonnenschein & Co., Paternoster Square, London, E.C.

RANUNCULACEÆ.

1. TRAVELLER'S JOY, (*Clematis vitalba*). Hedges and thickets, on a Calcareous soil. B. Hedges on Chalky soil, S. 1–1. Wenlock Limestone, North Malvern. Great Oolite, Ascott-under-Wychwood.

2. GREEN HELLEBORE — BEAR'S-FOOT, (*Helleborus viridis*). Thickets on a Calcareous soil. B. * Coc., Ulv., Ken.

3. STINKING HELLEBORE—SETTER WORT, (*Helleborus fœtidus*). Thickets in Chalky districts. B.

3A. COLUMBINE, (*Aguilegia Vulgaris*). *Pen., Coc., Ulv., Ken.

4. LARKSPUR, (*Delphinium Ajacis*). Sandy or Chalky cornfields. B.

5. BANEBERRY, (*Actœa spicata*). Mountainous Limestone tracts in the North. B.

6. PÆONY, (*Pœonia corallina*). On the Steep Holmes Island in the Severn. B. (An outlier of Mountain Limestone).

PAPAVERACEÆ.

7. LECOQ'S POPPY, (*Papaver Lecoqii*). Sides of fields chiefly on a Calcareous soil. B.

8. (*Roemeria hybrida*). Chalky cornfields in Cambridgeshire and Norfolk, very rare. B.

CRUCIFERÆ.

9. WALL-FLOWER, (*Cheiranthus Cheiri*). Old walls. B.

10. BITTER CRESS (Narrow-leaved Bitter Cress. S. 10–96), (*Cardamine impatiens*). Hilly districts, preferring Limestone. B. * Pen., Ken., W.Wa.

I may here note, that during the spring succeeding the floods in 1879, when the fluke-rot among sheep was so prevalent and destructive, the Common Cuckoo Flower, Bitter Cress, Lady's Smock, or May Flower, (*Cardamine pratensis*) which rejoices in *moist meadows*, was so abundant in the riparial areas of fully-formed rivers that had flooded the alluvial and clayey land they traversed during the previous

autumn, that when viewed from a height, the high-water mark of the floods could be traced for miles, owing to the land which they had covered being literally carpeted with the lilac-coloured flowers of this beautiful little spring plant.

11. WHITE MUSTARD, (*Sinapis alba*). Cultivated and waste calcareous land. B.

11A. HAIRY ROCK GRASS, (*Arabis hirsuta*). * Pen., Whi., Ken., W.Wa.

12. BROAD-LEAVED DRABA, OR WHITLOW GRASS, S. 9–89, (*Draba muralis*). Limestone hills. B.

12A. TWISTED PODDED DRABA, (*Draba incana*). * W.Wa.

13. PERFOLIATE PENNY CRESS, S. 7–68, (*Thlaspi perfoliatum*). Limestone in Oxfordshire and Gloucestershire. B.

14. ALPINE PENNY CRESS, S. (*Thlaspi alpestre*). Limestone rocks at Matlock. B.

15. BITTER CANDYTUFT, (*Iberis amara*). Chalky fields in South and East. B.

RESEDACEÆ.

16. WILD MIGNONETTE, (*Reseda lutea*). Waste Chalky and Limestone places. B.

17. WELD, (*Reseda Luteola*). Waste places, particularly on Chalk or Limestone. B.

CISTACEÆ.

18. HOARY ROCK ROSE, (*Helianthemum canum*). On Limestone rocks, rare. B. * Ulv., Ken.

19. COMMON ROCK ROSE, (*Helianthemum vulgare*). Common on dry, hilly pastures. B. Chalky pastures, others. * Pen., Ulv., Ken., W.Wa.

20. WHITE SUN CISTUS, S. 15–144, (*Helianthemum polifolium*). Brean Down, Somerset. B (a Mountain Limestone escarpment, of which Steep Holmes is an outlier—see Pæony) and Torquay, Devon. B.

VIOLACEÆ.

21. HAIRY VIOLET, (*Viola hirta*). Common on Limestone, Gogmagog hills, Portland. B. Chalky pastures. N.D.

POLYGALACEÆ.

22. LIMESTONE MILKWORT, (*Polygala calcarea*). Chalk hills, rare. B. Chalky Downs. N.D.

CARYOPHYLLACEÆ.

23. CHEDDAR PINK, MOUNTAIN PINK, S. 17–169, (*Dianthus cæsius*). Limestone cliffs at Cheddar, Somerset. B.

24. NOTTINGHAM CATCHFLY, (*Silene nutans*). On Limestone and Chalky places. Dover cliffs. B.

25. ALSINE, (*Alsine tenuifolia*). Sandy and Chalky places, rare. B.

26. FRINGED SANDWORT, S. 21–209, (*Arenaria ciliata*). Limestone cliffs of King Mountain, Co. Sligo. B.

27. FIELD MOUSE-EAR, or CHICKWEED, (*Cerastium arvense*). In Sandy, Gravelly, and Chalky places, rare. B.

HYPERICACEÆ.

28. HILL ST. JOHN'S WORT, S. 25–241, (*Hypericum montanum*). Bushy Limestone hills. B. * Whi., Ulv., Ken., W.Wa.

GERANIACEÆ.

29. LONG-STALKED CRANE'S BILL, S. 27–267, (*Geranium columbinum*). On Gravelly and Limestone soils. B.

LINACEÆ.

30. NARROW-LEAVED FLAX, S. 23–228, (*Linum angustifolium*). Sandy and Chalky places in the South. B.

31. PERENNIAL FLAX, (*Linum perenne*). Chalky places, rare. B.

LEGUMINOSÆ.

32. SAINFOIN, COCK'S HEAD, (*Onobrychis sativa*). On chalky and Limestone hills. B. Chalky pastures, N.D. 142. St. Kitts Quarries, Burford, Oxon, Gt. Oolite.

33. HORSESHOE VETCH, (*Hippocrepis comosa*). Dry Cal-

careous banks. B. Chalky pastures. N.D. 142. * Ulv., Ken., W.Wa.

ROSACEÆ.

34. COMMON DROPWORT, (*Spiræa filipendula*). Dry Chalky and Limestone pastures. B. * Whi., Ulv., Ken.

35. SALAD BURNET, LESSER BURNET, (*Poterium Sanguisorba*). On a dry Calcareous soil. B. Chalk heaths, N.D. 126. Ascott-under-Wychwood, Oxon., Gt. Oolite. * Pen., Whi., Ulv., W.Wa.

36. MOUNTAIN AVENS, S. 37–362, (*Dryas octopetala*). Alpine situations, particularly on Limestone. B.

37. WHITE BEAM TREE, S. 44–436, (*Pyrus Aria*). Chalky banks and Limestone rocks. B. * Ulv., Ken.

CRASSULACEÆ.

38. ROCK STONECROP, (*Sedum rupestre*). On Limestone rocks. Bristol, Cheddar, Orme's Head. B.

UMBELLIFERÆ.

39. LARGE EARTH-NUT, (*Carum* [*Bunium*, S.] *bulbocastanum*). Chalky fields in Cambs., Bucks., Beds., and Herts. B.

40. MOUNTAIN STONE PARSLEY, (*Seseli Libanotis*). Chalk hills of Cambs., Herts., and Sussex. B.

41. PARSNIP, (*Pastinaca sativa*). Hedge banks on a Calcareous soil. B.

42. SMALL BUR PARSLEY, S., HEN'S FOOT, (*Caucalis daucoides*). Cornfields, on a Chalky soil. B.

43. GREAT BUR PARSLEY, S., (*Caucalis latifolia*). Cornfields, mostly on a Chalky soil, very rare. Formerly abundant in Cambridgeshire.

CAPRIFOLIACEÆ.

44. MEAL-TREE, S. MEALY GUELDER-ROSE, (*Viburnum lantana*). A wayfaring tree. Hedges and thickets, on a Calcareous soil. B. Gt. Oolite, Oxon.

RUBIACEÆ.

45. QUINANCY WORT, (*Asperula cynanchica*). Dry banks in Limestone districts. B. * Ulv., Ken.

46. CORN BEDSTRAW, (*Galium tricorne*). Dry Calcareous fields. B.

46A. LITTLE MOUNTAIN BEDSTRAW, (*Galium Sylvestre*). * Ulv., Ken., W.Wa.

DIPSACACEÆ.

47. SMALL SCABIOUS, (*Scabiosa Columbaria*). On a Calcareous soil. B. * Pen., Whi., Ulv., Ken., W.Wa.

47A. FIELD SCABIOUS, (*Knautia arvensis*). Carboniferous Limestone, Kendal Fell.

COMPOSITÆ.

48. COLT'S FOOT, (*Tussilago Farfara*). Moist Chalky and Clay soils. B.

49. GOLDILOCKS, (*Linosyris vulgaris, Chrysocoma Linosyris.* S.). Limestone cliffs, rare. B.

50. PLOUGHMAN'S SPIKENARD, (*Inula Conyza*). Calcareous soils. B. * Ulv., Ken.

51. CROSS-LEAVED RAGWORT, (*Senecio erucifolius*). Calcareous soils. B.

52. WILD RAGWORT, (*Senecio campestre*). Chalk downs. B.

53. WOOLLY-HEADED THISTLE, (*Carduus eriophorus*). Waste ground on a Limestone soil. B. North Malvern, Wenlock Limestone.

54. GROUND THISTLE, (*Carduus acaulis*). Dry Calcareous pastures—Saffron Walden, Essex. B.

55. CHICORY, (*Cichorium Intybus*). Waste places on a Gravelly or Chalky soil. B. Heights near Andover, Hants, and Dartford, Kent.

56. SPOTTED CAT'S EAR, (*Achyrophorus* [*Hypochœris.* S.] *Maculata*). Chalky and Limestone hills. B. * Ulv.

57. LETTUCE, (*Lactuca saligna*). Chalky places, and near the sea. B.

58. DANDELION-LEAVED HAWK'S-BEARD (*Crepis taraxacifolia*). Limestone districts. B.

59. STINKING HAWK'S-BEARD, (*Crepis fœtida*). Chalky places, rare. B.

60. ROUGH HAWK'S-BEARD, (*Crepis biennis*). Chalky places, rare? B.

CAMPANULACEÆ.

61. RAMPION, (*Phyteuma orbiculare*). Chalky downs. B.

62. CLUSTERED BELL-FLOWER, (*Campanula glomerata*). Dry Calcareous pastures. B. Kendal. Gt. Oolite. Ascott-under-Wychwood, Oxon.

62A. MARJORAM, (*Origanum vulgare*). * Pen., Ulv., Ken., W. Wa.

GENTIANACEÆ.

63. YELLOW WORT, (*Chlora perfoliata*). Damp, Chalky places. B.

64. AUTUMN GENTIAN, S. 82–817,—FELWORT, B. (*Gentiana Amarella*). Dry Calcareous fields. B.

64A. FIELD GENTIAN (*Gentiana campestris*). Dry Limestone hills. B. Common on the Chalk. S. 82–818.

BORAGINACEÆ.

64B. GROMWELL, (*Lithospermum officinale*). * Coc., Ulv., Ken.

64C. CREEPING GROMWELL, (*Lithospermum purpuro-cœruleum*). Thickets on a Limestone soil, rare. B.

OROBANCHACEÆ.

65. HENBANE, (*Hyoscyamus niger*). Waste places, preferring a Calcareous soil. B.

SCROPHULARIACEÆ.

65A. CREEPING TOAD-FLAX, (*Linaria repens*). Calcareous soil, particularly near the sea. B.

66. SPIKED SPEEDWELL, (*Veronica spicata*). Rare, on chalky

heaths near Newmarket and Bury; and on Limestone cliffs. B.

LABIATÆ.

67. THYME, (*Thymus Serpyllum*). Dry heaths. B. Limestone, near Kendal. Gt. Oolite-Ascott-under-Wychwood, Oxon.

68. CALAMINT, BASIL THYME, S. 98–972. BASIL, (*Calamintha Acinos*). Dry Gravelly places and Limestone rocks. B.

69. HEN-BIT, DEAD-NETTLE, (*Lamium amplexicaule*). Sandy and Chalky fields. B.

70. WHITE DEAD NETTLE, (*Lamium album*). Abundant on Oolitic Limestone near Ascott-under-Wychwood, Oxon.

71. DOWNY WOUNDWORT, (*Stachys germanica*). Chalky soil, Oxfordshire. B.

PLANTAGINACEÆ.

72. LAMB'S TONGUE, (*Plantago media*). Chalky pastures. N.D. 144.

SANTALACEÆ.

73. (*Thesium humifusum*). Chalky and Limestone (Oolite) hills. B.

EUPHORBIACEÆ.

74. BOX, (*Buxus sempervirens*). Dry Chalky hills, especially in Surrey and Kent. Rare. B.

74A. UPRIGHT SPURGE, (*Euphorbia stricta*). Limestone woods in the West. S. 167–1662.

AMENTIFERÆ.

75. BEECH, (*Fagus sylvatica*). Woods, particularly on Calcareous soils. B.

CONIFERÆ.

76. YEW, (*Taxus baccata*). Mountainous woods and Limestone cliffs. B. Yewdale, English Lake District.

77. JUNIPER, (*Juniperus communis*). Dry hills, especially on a Calcareous soil. B.

ORCHIDACEÆ.

78. PURPLE ORCHIS, (*Orchis purpurea*, S. 123–1223). Chalky bushy hills in Kent. B. Chalk hills. S.

79. MAN ORCHIS, (*Orchis militaris*). Chalky hills, Berks., Oxon., Bucks., Herts. B.

80. MONKEY ORCHIS, (*Orchis Simia—Orchis Tephrosanthos*, S.). Chalky hills in Berks., Oxford, and Kent. B. Chalk hills. S.

81. DWARF DARK-WINGED ORCHIS, (*Orchis ustulata*). Calcareous hills. B. Chalky pastures. N.D. 153, and S. 123–1221.

82. PYRAMIDAL ORCHIS, (*Orchis pyramidalis*). Calcareous pastures. B. Chalky pastures. N.D. 172.

83. LIZARD ORCHIS, (*Orchis hircina*). Bushy Chalk hills, very rare. Kent, Surrey, Great Glenham, Suff. B. Chalky thickets. S.

84. FRAGRANT ORCHIS, (*Gymnadenia conopsea*). Hilly pastures. B. Chalky heaths. N.D. 162. Chalk hills. S.

85. GREEN MAN ORCHIS, (*Aceras anthropophora*). Dry Chalky places. B. Chalk hills. S.

86. (*Neotinea intacta*). Open limestone pastures at Castle Taylor and elsewhere, Co. Galway. B.

87. BEE ORCHIS, (*Ophrys apifera*). On Calcareous soils. Reigate. B. Chalky pastures. N.D. Chalk hills. S. Blue Anchor, Somerset.

88. LATE SPIDER ORCHIS, (*Ophrys arachnites*). Chalk downs, Folkestone and Sittingbourne, Kent. B. Chalk hills. S.

89. SPIDER ORCHIS, (*Ophrys aranifera*). Chalky places, rare. Kent, Sussex, and Isle of Wight. B. Chalk hills. S.

90. FLY ORCHIS, (*Ophrys muscifera*). Damp Calcareous thickets and pastures. B. Chalk hills. S. * Ulv., Ken., W.Wa.

90A. MUSK ORCHIS, (*Herminium Monorchis*). Calcareous soil in the South, rare. B.

91. AUTUMN LADY'S TRESSES, (*Spiranthes autumnalis*). Dry Calcareous and Gravelly places. B. * Ulv.

92. LARGE FLOWERED HELLEBORINE, (*Cephalanthera grandifolia*). Woods, usually on a Calcareous soil. B.

92A. SWORD-LEAVED HELLEBORINE, (*Cephalanthera ensifolia*). * Coc., Ulv., Ken., W.Wa.

LILIACEÆ.

93. TULIP, (*Tulipa sylvestris*). Chalk pits in the Eastern counties. "Meadows near Nottingham and in Yorkshire." B. Chalky fields, local. S.

93A. LILY OF THE VALLEY, (*Convallaria majalis*). * Ulv., Ken., W.Wa.

93B. ANGULAR SOLOMON'S SEAL, (*Polygonatum officinalis*). * Ken.

CYPERACEÆ.

94. DWARF SILVERY SEDGE, (*Carex humilis, clandestina*). S. Limestone hills in Wilts, Dorset, and Somerset. B. near Bristol. S.

94A. BIRD'S FOOT SEDGE, (*Carex ornithopoda*). * Ken.

95. FINGERED SEDGE, (*Carex digitata*). Woods on Limestone, rare. B.

GRAMINEÆ.

95A. MOOR GRASS, (*Sesleria cœrulea*). * Ulv., Ken., W.Wa.

96. PURPLE STALKED CAT'S-TAIL GRASS, (*Phleum Boehmeri*). Dry Chalky fields, rare. B.

97. DOWNY OAT-GRASS, (*Avena pubescens*). Chalky and Limestone districts. B. Chalky pastures. N.D. 133. S.

97A. NARROW-LEAVED OAT-GRASS, (*Avena pratensis*). * Ken., W.Wa.

98. YELLOW OAT-GRASS, (*Trisetum* [*Avena*, S.], *flavescens*). Fields. B. Chalky fields. S. Chalky pastures. N.D. 158.

99. HEATH BROME-GRASS, (*Brachyopodium pinnatum*). On dry Limestone soil. B.

100. QUAKING GRASS, (*Briza media*). Dry and Sandy fields.

B. Downs, S. Limestone, Kendal. Gt. Oolite, Ascott-under-Wychwood.

101. WOOD BARLEY, (*Hordeum sylvaticum*). Woods and thickets, on a Calcareous soil, rare. B. * Ulv.

102. RIGID THREE-BRANCHED POLYPODY, (*Polypodium Robertianum* [*calcareum*, S.]). On broken Limestone ground. B. Limestone districts. S. 172–1716. * Ulv., Ken.

103. RIGID LASTREA, (*Lastrea rigida*). * Ulv., Ken.

APPENDIX B.—POPULATION.

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
	40. CUMBERLAND.				
	568. ALSTON.				
1. Alston	Alston (W)	2839	2253	2841	2368
	569. PENRITH.				
1. Penrith	Melmerby	141	138	138	148
	Ousby	154	118	175	125
	Kirkland and Blencarn	113	98	95	77
	Skirwith	160	131	130	145
	Culgaith	262	173	205	174
	Langwathby	231	172	186	169
	Edenhall	144	139	137	131
	Penrith (W)	3941	4340	4376	4928
	Dacre	439	476	470	489
	Newton Regny	70	75	79	96
	Catterlin	79	59	71	57
	Plumpton Wall	167	182	147	163
2. Greystoke	Hutton in the Forest	156	132	129	112
	Greystoke, Johnby, Little Blencow, and Motherby and Gill	263	281	282	327
	Hutton Soil	195	203	220	181
	Hutton John	22	22	22	25
	Watermillock	255	220	265	225
	Matterdale	223	190	203	174
	Threlkeld	202	216	176	203
	Mungrisdale	110	93	91	87
	Bowscale	15	15	17	17
	Berrier and Murrah	48	57	53	46
	Hutton Roof	80	89	89	78
	Mosedale	23	24	26	22
	Castle Sowerby	411	376	422	389
	Skelton	355	395	349	331
	Middlesceugh with Braithwaite	86	80	62	65
3. Kirkoswald	Hesket in the Forest	1157	1063	993	902
	Lazonby	718	320	405	330
	Salkeld Great	255	258	220	243
	Hunsonby and Winskel	217	158	145	126
	Salkeld Little	95	73	78	53
	Glassonby	87	93	73	72
	Gamblesby	139	151	134	118
	Renwick	127	130	135	128
	Kirkoswald	361	298	346	297
	Staffield	138	132	137	115
	Ainstable	274	231	268	222
	Croglin	131	124	144	127

Registration District.		Population.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
	570. BRAMPTON.				
1. Hayton	Cumrew	75	73	62	49
	Carlatton	41	45	25	22
	Cumwhitton	282	261	227	236
	Castle Carrock	166	145	143	151
	Geltsdale Forest	8	8	6	3
	Hayton	687	700	747	720
2. Brampton	Brampton (*W*)	1733	1685	1824	1753
	Farlam	721	852	641	733
	Midgeholme	67	83	52	59
	Denton Nether	148	159	143	156
	Denton Upper	51	75	55	77
	Waterhead, *part of* [1]	42	51	34	35
	Burtholme, *part of* [2]	13	1	12	—
3. Walton	Burtholme, *part of* [2]	150	144	162	154
	Waterhead, *part of* [1]	117	113	146	125
	Kingwater	181	169	181	162
	Askerton	181	172	147	146
	Irthington	431	423	467	430
	Walton	215	195	225	200
	571. LONGTOWN.				
1. High Longtown	Stapleton	211	182	209	190
	Solport	132	146	117	103
	Trough	76	67	61	59
	Bellbank	56	49	59	45
	Bewcastle	543	468	501	421
	Nichol Forest	340	328	316	299
2. Low Longtown	Kirk Andrews Moat Quarter	88	105	74	81
	" Middle Quarter	159	150	166	139
	" Nether Quarter	178	186	154	183
	Arthuret (*W*) (including Longtown)	1388	1300	1459	1311
	West Linton	252	226	234	215
	Kirk Linton Middle Quarter	218	202	199	204
	Hethersgill	295	277	311	310
	Scaleby	238	230	234	235
Entire Civil Parishes:					
[1] Waterhead		159	164	180	160
[2] Burtholme		163	145	174	154

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
	572. CARLISLE.				
1. Wetheral .	Crosby upon Eden	180	186	214	207
	Warwick	156	153	169	167
	Wetheral	1663	1585	1629	1735
2. St. Cuthbert .	Carlisle St. Cuthbert Without (*W*) (*W S*)	5946	7180	6241	7308
	Carlisle St. Cuthbert Within . .	1380	1286	1542	1321
	Wreay.	93	91	83	90
3. St. Mary . .	Carlisle St. Mary Within . . .	1740	1519	2127	1823
	Rickergate	1761	2237	2232	2911
	Caldewgate.	5070	6661	5592	7018
	Eaglesfield Abbey	18	22	31	42
4. Stanwix . .	Stanwix	1147	1301	1386	1576
	King Moor	236	251	225	228
	Rockliff	374	379	410	375
5. Burgh . .	Grinsdale	54	60	58	57
	Kirk Andrews upon Eden . . .	65	79	66	66
	Beaumont	109	117	125	119
	Burgh by Sands.	410	385	493	477
6. Dalston . .	Orton	225	227	227	227
	Cummersdale	343	417	360	431
	Dalston	1169	1119	1278	1329
	573. WIGTON.				
1. Wigton . .	Thursby	252	251	267	282
	Kirk Bampton	193	201	212	219
	Bowness	587	662	607	707
	Kirkbride	180	177	207	186
	Aikton	389	381	419	408
	Oulton	181	192	180	178
	Wigton (*W*)	1738	1685	2068	2065
	Woodside Quarter	304	284	315	305
	Waverton	281	254	259	227
	Holme East Waver	246	223	249	229
2. Abbey Holme .	Low Holme.	870	1025	1036	1067
	Holme St. Cuthbert	381	366	372	382
	Abbey Holme	502	468	431	470
	Skinburness Marsh [common to the Townships of Low Holme, Holme St. Cuthbert, and Abbey Holme.]	—	—	—	—
	Dundraw and Kelsick . . .	145	131	145	111

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
	573. WIGTON—*continued.*				
2. Abbey Holme —*continued*	Blencogo	113	95	113	95
	Bromfield	190	192	189	186
	Langrigg and Mealrigg	146	138	142	139
	West Newton and Allonby	443	408	518	460
	Hayton and Mealo	174	158	158	137
	Aspatria and Brayton	906	1197	872	1211
	Blennerhasset and Kirkland	172	247	175	243
	Torpenhow and Whitrigg	136	144	152	134
	Allhallows	109	390	113	346
3. Caldbeck	Bolton High	158	145	140	127
	Bolton Low, *or* Bolton Wood, and Quarry Hill	300	337	273	299
	Westward	545	530	520	514
	Sebergham	325	282	320	269
	Caldbeck	811	563	768	613
	Ireby Low	155	154	159	158
	Ireby High	62	63	53	46
	Uldale	134	138	131	116
	574. COCKERMOUTH.				
1. Keswick	Bewaldeth and Snittlegarth	47	45	46	45
	Embleton	174	167	165	180
	Wythop	44	56	46	58
	Bassenthwaite	274	267	276	242
	Keswick	1271	1443	1506	1758
	Castlerigg St. John and Wythburn	310	308	355	367
	Underskiddaw	231	246	268	280
	Borrowdale	185	236	212	213
	Above Derwent	448	441	508	483
	Briery Cottages	21	45	17	47
	Skiddaw	7	7	3	3
2. Cockermouth	Lorton	188	179	211	218
	Brackenthwaite	53	58	54	60
	Loweswater	190	163	182	152
	Whinfell	49	56	62	59
	Buttermere	54	62	51	65
	Mosser	45	37	38	39
	Brigham	352	387	393	403
	Eaglesfield	126	134	142	124
	Cockermouth (*W*)	2354	2532	2761	2821
	Blindbothel	44	36	46	45
	Setmurthy	81	91	90	82
	Isell Old Park	40	34	35	33

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
	574. COCKERMOUTH—*continued.*				
2. Cockermouth —*continued* .	Sunderland	38	28	32	35
	Blindcrake, Isell, and Redman	146	148	152	177
	Bridekirk	61	40	78	47
	Papcastle	288	319	381	381
	Broughton Little	413	411	379	387
	Broughton Great	531	592	493	529
3. Workington .	Seaton	1069	1534	902	1370
	Camerton	114	137	112	102
	Ribton	14	11	8	7
	Greysouthen	382	333	365	357
	Clifton Little	314	262	285	227
	Clifton Great	346	507	314	467
	Stainburn	90	108	100	119
	Workington	4143	7497	4270	6864
	Winscales	60	56	60	47
	Cloffocks	—	5	—	5
	Dean	380	412	398	413
4. Maryport .	Dovenby	130	114	128	113
	Tallentire	102	104	110	113
	Gilcrux	340	261	302	253
	Plumbland	369	323	391	327
	Bothel and Threapland	205	192	209	200
	Oughterside and Allerby	372	267	295	233
	Cross Cannonby with Maryport	3912	3964	3930	4332
	Dearham	974	1199	961	1047
	Ellenborough and Ewanrigg	664	1513	665	1370
	Flimby	884	1106	829	1017
	575. WHITEHAVEN.				
1. Harrington .	Harrington	1112	1536	1182	1483
	Distington	470	672	485	617
	Arlecdon	1876	3562	1550	3089
	Lamplugh	553	669	502	592
	Salter and Eskat	71	108	57	88
	Ennerdale and Kinniside	350	269	316	265
	Weddicar	34	39	28	30
	Morseby	243	484	311	473
	Parton	454	794	404	685
2. Whitehaven .	Whitehaven	6461	6512	6837	6862
3. St. Bees .	Hensingham	1068	1027	1027	1037
	Preston Quarter (W)	2817	3479	3046	3518

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
	575. WHITEHAVEN—*continued.*				
3. St. Bees—*cont.*	Sandwith	156	162	165	160
	Rottington	23	33	20	34
	Lowside Quarter	140	150	150	164
	St. Bee's	552	548	570	594
4. Egremont	Cleator	3843	5428	3218	4992
	Egremont	2362	3124	2167	2852
	Haile	150	142	152	151
	Beckermet St. John	223	289	236	334
	Beckermet St. Bridget	316	305	364	356
	Ponsonby	90	86	84	80
	Gosforth	550	587	598	640
	Nether Wasdale	106	95	83	96
	576. BOOTLE.				
1. Muncaster	Eskdale and Wasdale Head	194	288	167	247
	Birker and Austhwaite	57	65	49	42
	Irton, Santon, and Melthwaite	308	326	289	288
	Drigg	246	275	239	292
	Muncaster	289	321	280	317
	Waberthwaite	107	104	89	90
2. Bootle	Corney	118	111	108	99
	Bootle (*W*)	394	414	401	396
	Whitbeck	108	96	75	88
	Whicham	177	207	172	167
	Millom	2309	4021	1998	3677
	Ulpha	190	161	161	133

41. WESTMORELAND.

	577. EAST WARD.				
1. Appleby	Newbiggin	61	65	55	74
	Milbourne	133	117	143	125
	Temple Sowerby	240	193	236	227
	Kirkby Thore	304	257	234	256
	Long Marton	417	351	417	358
	Dufton	245	216	226	198
	Appleby St. Michael, *or* Bongate	851	716	694	727
	Appleby St. Lawrence	868	716	812	740
	Ormside	479	109	207	103

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
577. EAST WARD—*continued.*					
2. Kirkby Stephen	Warcop	437	365	376	355
	Musgrave Great	93	95	94	87
	Brough	314	314	355	314
	Hilbeck	43	33	24	23
	Stainmore	268	254	268	240
	Brough Sowerby	67	74	58	59
	Kaber	91	97	101	103
	Winton	127	121	117	129
	Hartley	82	78	85	71
	Kirkby Stephen (*W*)	970	812	901	852
	Nateby	130	92	92	83
	Wharton	61	33	39	28
	Mallerstang	390	153	195	118
	Smardale	126	21	54	23
	Waitby	73	38	28	30
	Soulby	280	126	178	149
	Musgrave Little	31	36	27	35
	Crosby Garrett	406	114	179	110
3. Orton	Ravenstonedale	520	453	478	436
	Orton	865	992	800	925
	Ashby	241	235	251	261
578. WEST WARD.					
1. Morland	Crosby Ravensworth	468	423	441	361
	Crosby Ravensworth Fells [common to the township of Birkbeck Fells and to part of the township of Crosby Ravensworth]	—	—	—	—
	Birkbeck Fells Common [common to the township of Birkbeck Fells and to part of the township of Crosby Ravensworth]	—	—	—	—
	Birkbeck Fells Common [common to the township of Birkbeck Fells and to part of the township of Crosby Ravensworth]	—	—	—	—
	Bank Moor [common to parts of the townships of Crosby Ravensworth and Asby]	—	—	—	—
	Undivided Moor [common to the township of Birkbeck Fells and to part of the township of Crosby Ravensworth]	—	—	—	—
	Shap (*W*)	710	748	560	668
	Strickland Little	57	66	51	48

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
578. WEST WARD—*continued.*					
1. Morland—*cont.*	Thrimby	33	31	29	22
	Strickland Great	143	147	141	136
	Newby	122	123	121	122
	Sleagill	76	71	90	69
	Kings Meaburn	101	87	92	90
	Bolton	186	216	191	188
	Morland	185	173	197	198
	Cliburn	153	138	151	141
2. Lowther	Brougham	141	157	109	139
	Clifton	167	182	174	211
	Lowther	201	232	222	238
	Askham	231	255	252	258
	Winder Low	12	12	9	8
	Barton High	163	181	181	190
	Stockbridge and Tirril	109	101	117	117
	Yanwath and Eamont Bridge	171	149	156	140
	Martindale	87	69	84	73
	Patterdale with Hartsop	433	380	372	330
	Undivided Moor in Barton Parish	—	—	—	—
	Bampton	278	254	281	283
579. KENDAL.					
1. Ambleside	Grasmere	379	330	426	406
	Langdale	380	388	306	338
	Rydal and Loughrigg	202	221	231	277
	Ambleside	906	907	1082	1082
	Troutbeck	216	214	202	232
	Applethwaite	791	882	739	1030
	Undermilbeck	896	1039	1052	1197
	Crook	158	137	121	142
	Hugil	215	206	206	186
	Kentmere	96	89	83	85
	Over Staveley	358	376	327	354
	Nether Staveley	146	166	140	158
2. Grayrigg	Fawcet Forest	29	32	22	24
	Whinfell	97	87	83	86
	Selside and Whitwell	127	122	98	122
	Patton	48	31	50	32
	Grayrigg	125	126	120	102
	Dillicar	88	67	73	55
	Lambrigg	79	84	68	84
	Docker	43	40	35	29
	Scalthwaiterigg, Hay, and Hutton-i'-the-Hay	250	276	238	263

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
REGISTRATION SUB-DISTRICT.	Civil Parish or Township.	1871.	1881.	1871.	1881.
579.	KENDAL—*continued.*				
2. GRAYRIGG—*cont.*	Skelsmergh	186	197	164	170
	Strickland Roger	213	215	235	219
	Strickland Kettle	281	300	306	313
	Long Sleddale	72	67	76	69
	New Hutton	80	63	60	57
	Old Hutton with Holmescales	205	186	200	195
	Firbank	110	114	93	93
3. KIRKBY LONSDALE	Killington	149	129	122	119
	Middleton	143	121	142	110
	Barbon	131	137	137	138
	Casterton	139	145	372	436
	Kirkby Lonsdale	901	841	865	892
	Mansergh	130	114	117	125
	Lupton	136	119	109	98
	Hutton Roof	153	156	135	139
	Farleton	39	41	30	37
	Burton in Kendal	319	332	360	343
	Holme	328	378	370	401
	Preston Patrick	272	280	237	264
	Preston Richard	280	301	249	288
	Dalton (*Lancashire*)	67	70	53	53
4. KENDAL	Natland	140	151	115	136
	Kendal *or* Kirkby Kendal (*W*)	5663	5561	6250	6158
	Nether Graveship	61	282	68	326
	Kirkland	684	657	720	712
5. MILNTHORPE	Helsington	153	166	174	183
	Underbarrow and Bradley Field	246	229	238	235
	Crosthwaite and Lyth	371	407	345	364
	Levens	478	496	457	449
	Sedgewick	130	134	117	113
	Stainton	188	193	190	195
	Hincaster	72	56	57	61
	Heversham with Milnthorpe (*W*)	665	774	750	771
	Haverbrack	38	57	56	63
	Beetham	393	461	380	526
	Meathop and Ulpha	75	88	58	60
	Witherslack	292	276	224	265

REGISTRATION DISTRICT.		POPULATION.			
		Males.		Females.	
Registration Sub-District.	Civil Parish or Township.	1871.	1881.	1871.	1881.
34. LANCASHIRE.					
481. ULVERSTON.					
1. Cartmel	Upper Allithwaite	395	361	381	352
	Cartmel Fell	158	169	139	124
	Staveley	218	206	220	220
	East Broughton	410	531	597	720
	Lower Allithwaite	423	440	586	535
	Lower Holker	564	549	551	544
	Upper Holker	424	415	426	434
	East Plain — Reclaimed Lands claimed by all the Townships in the Parish of Cartmel	—	—	—	—
	West Plain — Reclaimed Lands claimed by all the Townships in the Parish of Cartmel	—	—	—	—
	Out Marsh (Reclaimed Land)	—	—	—	—
2. Colton	Colton	931	935	929	848
	Blawith	66	76	80	82
	Subberthwaite	79	78	67	71
	Lowick	234	195	229	181
	Egton with Newland	596	490	552	508
	Lands over which the inhabitants of Lowick claim intercommonage with the inhabitants of Lower Subberthwaite	—	—	—	—
3. Ulverston	Mansriggs	37	31	36	33
	Osmotherley	208	243	197	231
	Ulverston (*W*)	3627	4948	3980	5060
	Pennington	585	872	527	826
4. Dalton	Urswick	573	670	571	617
	Aldingham	562	570	499	582
	Dalton-in-Furness	4977	7125	4006	6214
5. West Broughton	Kirkby Ireleth	906	897	857	825
	West Broughton	539	570	546	601
	Dunnerdale with Seathwaite	156	159	135	140
	Angerton	21	20	15	12
6. Hawkshead	Torver	113	100	96	102
	Church Coniston	579	492	527	478
	Hawkshead with Monk Coniston and Skelwith	524	584	561	621
	Claife	283	258	280	289
	Satterthwaite	213	245	181	207
482. BARROW-IN-FURNESS.					
1. Barrow-in-Furness	Barrow-in-Furness (*W*)	10902	25575	8009	21684

Ages of Males and Females in Registration Districts, 1881.

Registration District.	All Ages. Persons.	All Ages. Males and Females.	Under 5 Years.	5–	10–	15–	20–	25–	30–	35–	40–	45–	50–	55–	60–	65–	70–	75–	80–	85–	90–	95–	100 and upwards.
40 CUMBERLAND.																							
568 ALSTON	4621	M. 2253	269	274	271	245	183	169	130	131	118	112	118	86	60	42	24	11	6	3	1	...	...
		F. 2368	265	283	266	245	196	164	121	137	134	124	113	90	81	70	29	32	11	4	...	...	...
569 PENRITH	23242	M. 11525	1466	1432	1276	1245	968	796	647	653	543	494	439	446	391	306	206	119	71	26	1	...	...
		F. 11717	1130	1316	1233	1173	1092	885	728	652	594	515	489	451	379	288	235	154	68	30	4	1	...
570 BRAMPTON	10565	M. 5354	632	614	621	573	468	389	355	291	255	208	217	202	157	137	111	73	40	10	1	...	...
		F. 5211	589	572	532	522	504	387	337	317	219	244	220	201	179	126	111	60	43	12	5	...	1
571 LONGTOWN	7711	M. 3916	465	476	408	409	342	238	249	202	188	174	176	141	139	121	100	47	26	12	3	...	...
		F. 3795	480	415	413	377	336	257	228	221	191	181	152	137	123	104	100	45	25	5	3	1	1
572 CARLISLE	52762	M. 25255	3454	2992	2770	2609	2231	2063	1685	1451	1316	1063	980	782	674	478	345	193	110	24	5	...	...
		F. 27507	3403	3047	2765	2729	2576	2362	1867	1622	1478	1252	1108	937	896	621	443	234	114	43	10	...	...
573 WIGTON	23440	M. 11481	1520	1353	1282	1204	908	824	698	594	643	486	446	371	383	315	218	140	76	12	7	1	...
		F. 11959	1512	1385	1276	1101	1020	891	720	665	574	539	539	437	418	350	252	169	75	29	4	3	...
574 COCKERMOUTH . .	56789	M. 28473	4190	3625	3043	2620	2747	2430	1900	1603	1501	1166	989	807	750	472	332	168	91	35	4	...	...
		F. 28316	4267	3648	3074	2603	2420	2124	1780	1590	1420	1200	1038	881	830	615	429	228	126	34	8	1	...
575 WHITEHAVEN . . .	59292	M. 30100	4501	3931	3338	2952	2761	2581	2153	1827	1603	1202	1026	677	671	414	272	121	53	14	1	1	1
		F. 29192	4605	3917	3256	2713	2505	2160	1887	1680	1521	1214	1001	788	743	522	351	185	95	37	8	1	...
576 BOOTLE	12225	M. 6389	952	808	655	653	560	528	490	356	311	257	214	169	159	129	74	41	22	9	2	...	...
		F. 5836	976	729	667	559	481	454	389	322	275	221	204	165	144	121	64	40	22	1	1	1	...
41 WESTMOR-LAND.																							
577 EAST WARD	14515	M. 7276	913	930	812	697	537	502	443	369	383	332	327	282	282	191	127	87	45	14	3	...	...
		F. 7239	984	789	781	693	625	529	469	378	395	332	312	253	221	188	145	79	47	12	6	1	...
578 WEST WARD . . .	8225	M. 4195	509	507	507	412	360	281	250	229	193	189	182	137	157	108	79	59	27	6	3	...	...
		F. 4030	484	478	446	387	337	305	221	207	194	213	185	150	138	123	77	53	24	6	2	...	...
579 KENDAL	41574	M. 20114	2713	2563	2331	2053	1663	1450	1270	1097	959	862	720	682	628	470	310	228	86	22	5	1	1
		F. 21460	2734	2558	2435	2168	1905	1663	1372	1237	1084	918	819	735	625	481	377	206	100	33	6	2	2
34 LANCASHIRE.																							
481 ULVERSTON	43681	M. 22229	3274	2909	2508	1978	1923	1747	1475	1325	1162	890	802	651	602	396	298	185	76	23	5	...	...
		F. 21452	3329	2840	2331	1838	1755	1690	1354	1232	1050	936	766	688	564	462	310	172	83	40	11	1	...

APPENDIX C.

Colour of Hair and Eyes in the Several Districts of Cumberland, Westmorland, and the Lake District.—From Dr. John Beddoe, F.R.S.—See supra, p. 225.

The Numbers in Dr. Beddoe's Work.	CUMBRIA.	Number.	Sex.	Eyes Light.					Eyes Light.	Eyes Intermediate or Neutral.					Eyes Intermediate or Neutral.	Eyes Dark.					Eyes Dark.
				Red.	Fair.	Brown.	Dark.	Black.		Red.	Fair.	Brown.	Dark.	Black.		Red.	Fair.	Brown.	Dark.	Black.	
131	Carlisle—City	342	both	16·5	46·5	120	38	2	223	3	4	9	18	2	36	2	7	28·5	36	9·5	83
132	Per cent.	...	...	4·8	13·6	35·1	11·1	·6	65·2	·9	1·2	2·6	5·3	·6	10·6	·6	2	8·3	10·5	2·8	24·2
133	Carlisle—Farmers	100	males	4	22	34	11	1	72	...	2	3	3	...	8	1	2	5	10	2	20
134	Do.—Peasants. Per cent.	400	both	4·9	20	36·1	12·3	...	73·3	·2	1·9	6	4·2	...	12·3	·3	·6	4·4	8	1·1	14·4
135	Cockermouth—Town	184	both	8	37	59	17·5	·5	122	...	1	7·5	6·5	...	15	3	3·5	15·5	23	2	47
136	Per cent.	...	...	4·3	20·1	32·1	9·5	·3	66·3	...	·5	4·1	3·5	...	8·1	1·6	1·9	8·4	12·5	1·1	25·5
137	Keswick—Town	134	both	7	20	50·5	9·5	...	87	...	2	7·5	7·5	...	17	...	2	7	19·5	1·5	30
138	Per cent.	...	...	5·2	14·9	37·7	7·1	...	64·9	...	1·5	5·6	5·6	...	12·7	...	1·5	5·2	14·6	1·1	22·4
139	Penrith—Town	130	both	4	23	42	13	...	82	...	4	3·5	8·5	...	16	1	...	13	15	3	32
140	Per cent.	...	...	3·1	17·7	31·9	10	...	62·7	...	3·2	2·7	6·5	...	12·4	·7	...	10	11·5	2·3	24·5
141	Peasants of the Cumberland Dales																				
	(a) Borrowdale, etc.	50	both	3	6	17·5	4·5	...	31	1	1	3	1·5	...	6·5	...	...	3·5	8	1	12·5
	(b) Round Keswick and Lorton	63	both	4	12	22	4	...	42	1	2	2	1	...	6	1	...	6·5	7	·5	15
	(c) Threlkeld, Greystoke, Langwathby	157	both	9·5	23·5	59·5	16	1·5	110	...	2	5	7·5	·5	15	...	1	7·5	23·5	...	32
	Total	270	...	16·5	41·5	99	24·5	1·5	183	2	5	10	10	·5	27·5	1	1	17·5	38·5	1·5	59·5
142	Per cent.	...	...	6·1	15·3	36·6	9·1	·5	67·6	·6	1·8	3·7	3·7	·2	10·0	·4	·4	6·5	14·2	·5	22

Dr. Beddoe in a recent communication tells me that he thinks there is more of the blood of the earlier races (generally but incorrectly called Celtic) in parts of the central mountain mass and of the Upper Eden Valley, than elsewhere; and that, if this be the case, it is what might have been expected from the nature of the country and the probable course of migration. Thus, the Norseman coming from the Isle of Man would first occupy the richer portions of the coastlands (the dark and light blue areas in the Contour Map) and the plains about Carlisle. The city of course would have a more mixed population.

With regard to Alston, Dr. Beddoe has been informed that *dark hair* is prevalent thereabout, as one might expect from the considerations just mentioned.

APPENDIX D.

THE COCCIDEAL ORIGIN OF CANCER.

Dr. G. Sims Woodhead, Director of the Research Laboratory of the Conjoint Board of the Royal Colleges of Physicians and Surgeons, in his recent (1892) "Morton Lecture," delivered at the Royal College of Surgeons, on "*The Etiology of Cancer*," gave an account of an organism that had been specially described as occurring in the liver of the rabbit, where, under the name *Coccidium*, it is known to set up a peculiar irritated condition of the bile ducts, which ends in the formation of *psorosperm nodules*, which are really cysts containing papilliform projections covered with rapidly proliferating epithelium, in the cells of which are numerous parasitic protoplasmic bodies.

These organisms, setting up similar proliferating changes, have also been described as present in the epithelial cells lining the intestines of the mouse, the dog, cat, rabbit, and even man.

Similar organisms, demonstrated as frequently present in cancerous tumours, do not necessarily pass through the whole stage of their life-history in the epithelial cells. It is known that in the case of the rabbit, *psorosperms* pass from the bile duct into the intestine, and so into the fæces, whence they reach the outer world.

Under certain conditions of moisture and heat, Dr. Woodhead tells us, *coccidia* in the rabbit form *psorosperms*—the small, more delicate forms *spores*—within the original capsule; the capsules burst, and the organisms may be taken again into the alimentary canal. Feeding experiments,

carried on by Leuckhart, Eimer, and others, have all gone to prove this; so that the question of the *endemic* nature of Cancer (see supra, p. 336), if it is proved that *coccidia* are its cause, or one of its causes, will have to be gone into more carefully than was at one time thought necessary. Dr. Woodhead concludes this part of his lecture in the following words: "Hirsch entirely pooh-poohs the idea that climatic influence and state of the soil can have anything to do with the comparative frequency of Cancer in certain districts. Haviland, however, maintains that in England Cancer is least prevalent on rocky ground and high-lying places, and most common in marshy regions and on the wet soil of river basins subject to inundations. The conditions present in these localities described by Haviland are exactly those necessary for the development of the psorosperms of rabbits, a disease which is always most frequently met with amongst rabbits whose run is over marshy grounds or over narrow areas where the drainage is imperfect."[1]

Should a coccidial origin of cancer be proved, we shall be very much reminded of the history of the parasite that is the *vera causa* of the Fluke-Rot. During the epidemic of this disease in England after the heavy rains of 1878–1879, I drew attention to the fact that the map of the geographical distribution of cancer resembled one of the distribution of the *fluke-rot* among sheep. For the maps showed (*a*) that throughout the inundated parts of England there were to be found the districts having the *highest* mortality from *cancer* among females, and (*b*) the *heaviest* losses from *sheep-rot*.

Hugh Miller has told us, that what is fraught with health to the existence of the vegetable kingdom, is in many instances a deadly poison to those of the animal. The *Lime* that destroys the reptiles, fish, and insects of a thickly-inhabited

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[1] *British Medical Journal*, May 7, 1892, p. 959.

lake or stream injures not a single flag or bulrush among the millions that line its edge.[1]

We know that salt and brackish water are fatal to the sheep-fluke and many other entozoa. Lime is fatal to fish. May not the scarcity of cancer in limestone districts be due to the destruction of the microzoa, such as the *coccidium*, which has been shown by Dr. Woodhead to infest the epithelial structures involved in cancer growths? Our future experiments, as Dr. Woodhead suggests, must be made outside the body, if this fact is to be ascertained.

Lawes and Gilbert, in *The Journal of the Royal Agricultural Society*, No. VIII., December 31, 1891, give a remarkable account of the influence of *bacteria* in the soil, and especially of their influence on Papilionaceæ, in the roots of which they produce what may be regarded as a benign tumour.

Laboulbine, in *The Comptes Rendus de l'Académie des Sciences*, March 28, 1892, describes galls, which appear almost certainly due to *Bacteria*. I have no space to enter more fully into this interesting subject, but I allude to it as pertinent to the views of Sir James Paget, already quoted (p. 327).

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[1] "*The Old Red Sandstone*," 1858, p. 243.

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